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MONTHLY WEATHER REVIEW

VOLUME 48, No. 4

APRIL, 1920

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1920

INTRODUCTION.

The MONTHLY WEATHER REVIEW contains (1) meteorological contributions, and bibliography including seismology; (2) an interpretative summary and charts of the weather of the month in the United States and on the adjacent oceans; and (3) climatological and seismological tables, dealing with the weather and earthquakes of the month.

The contributions are principally as follows: (*a*) Results of the observational or research work in meteorology carried on in the United States or other parts of the world, in the Weather Bureau, at universities, at research institutes, or by individuals; (*b*) abstracts or reviews of important meteorological papers and books, and (*c*) notes. In each issue of the REVIEW reviews, abstracts, and notes are grouped by subjects, roughly, in the following order: General works, observations and reductions, physical properties of the atmosphere, temperature, pressure, wind, moisture, weather; applications of meteorology, climatology, and seismology.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, **but the publication of contributions is not to be construed as official approval of the views expressed.**

The partly annotated bibliography of current publications is prepared in the Weather Bureau Library. *Persons or institutions receiving Weather Bureau publications free should send in exchange a copy of anything they may publish bearing upon meteorology, addressed "Library U. S. Weather Bureau, Washington, D. C.,"* in order that the monthly list of current works on meteorology and seismology may be as complete as possible. Similar contributions from others will be welcome. Bibliographies of selected subjects are published from time to time in the REVIEW or SUPPLEMENTS.

The section of the weather of the month contains (1) an interpretative discussion of the weather of North America and adjacent oceans, and some notes on the weather in other parts of the world; (2) details of the weather of the month in the United States; and (3) brief discussions of weather warnings, rivers and floods, and weather and crops. There are illustrative charts. The climatological tables comprise summaries of the weather and excessive precipitation data for about 210 stations in the United States, and summaries of the weather observed at about 30 Canadian stations.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are due especially to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
Meteorological and Seismological Service of Mexico.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The seismological tables contain, in a form internationally agreed on, the earthquakes recorded on seismographs in North and Central America. Dispatches on earthquakes felt in all parts of the world are published also.

Since it is important to have as the name of the month appearing on the cover of the REVIEW that of the period covered by the weather discussions and tables rather than that of the month of issue, the REVIEW for a given month does not appear until about the end of the second month following.

SUPPLEMENTS, containing kite observations, and others, containing monographs or specialized groups of papers, are published from time to time.

NOTES TO CONTRIBUTORS.

Authors are requested to accompany their papers submitted for publication with a brief opening synopsis. When an article deals with more than one subject—as, for example, a method of measurement—some experimental results and a theory, each subject should be summarized in a *separate paragraph*, with a title which clearly describes it.

When illustrations accompany an article submitted for publication in the MONTHLY WEATHER REVIEW, the places where they should appear in the text should be indicated, and legends or titles for them should be inserted just after the end of the article. As far as practicable the illustrations when accompanied by their legends should be self-explanatory—i. e., the data on them should leave no doubt of what they are intended to convey.

BACK NUMBERS OF THE REVIEW WANTED.

As the surplus of MONTHLY WEATHER REVIEW, February, April, June, July, and August, 1919, is exhausted, recipients who do not care to retain their copies will confer a favor by using attached addressed, franked slip. The return of other issues of 1919, 1920, and earlier years will also be appreciated.

MONTHLY WEATHER REVIEW

CHARLES F. BROOKS, Editor.

VOL. 48, No. 4.
W. B. No. 709.

APRIL, 1920.

CLOSED JUNE 5, 1920
ISSUED JUNE 25, 1920

PAPERS ON TORNADOES.

THE THIRTEEN TORNADOES OF MARCH 28, 1920.

INTRODUCTORY NOTE.

On the afternoon of March 28, 1920, at least 13 tornadoes occurred, 11 in Illinois, Wisconsin, Indiana, and Michigan, and two or more in Alabama and Georgia. All but one of the northern group occurred along a line of wind convergence between warm southeasterly and southwesterly winds, which progressed from eastern Iowa to eastern Michigan between 6 a. m. and 9 p. m. A similar condition, though less strongly marked, on the southern end of the line produced those in Alabama and Georgia. This line of wind convergence appears to have been associated with a cold wind from the west aloft. The running of such a current over the warm southerly wind readily contributed to the formation of tornadoes. The following papers present the information concerning the destruction, the paths of the storms, the conditions at the surface and aloft. These storms killed 163 people, injured several hundred, and destroyed property valued at probably $10,000,000.—EDITOR.

TORNADOES OF MARCH 28, IN NORTHEASTERN ILLINOIS.

By CHARLES L. MITCHELL, Meteorologist.

[Weather Bureau, Chicago, Ill., Apr. 28, 1920.]

Three distinct tornadoes occurred in northeastern Illinois between noon and 1 p. m. (Central Standard Time) on Sunday, March 28, and there is some evidence of still another of very limited extent. There were 28 known deaths, 300 persons were injured, and the property losses amounted to over $3,000,000.

The three in the order of their distance from the main storm center are called (1) the Elgin tornado, (2) the Melrose Park–Wilmette tornado, and (3) the Clearing tornado. The first crossed the extreme northwestern portion of Cook County, the second went all the way across, and the third occurred entirely within that county; moreover, the paths of both the Melrose Park–Wilmette and the Clearing tornadoes lie partly within the limits of the city of Chicago. (See fig. 1.) Previously, so far as known, but two tornadoes ever occurred in Cook County and only one of these, that of May 25, 1896, entered Chicago.

The weather map on the morning of the 28th showed extremely favorable conditions for the development of destructive local storms in Illinois and adjacent States. The center of a severe and widespread disturbance had moved northeastward, with gradually increasing intensity, from Colorado to northwestern Iowa with a central sea-level pressure of 28.96 inches at Sioux City. Thunderstorms were general from the middle and lower Missouri valley eastward to Lake Michigan and Indiana, and the temperature was from 20° to 25° F. above normal, accompanied by rather high humidity, over a large area. By noon the storm was central in southeastern Minnesota and the temperature at Chicago was 60°, with a relative humidity of 84 per cent. The tornadoes occurred in the southeastern quadrant of the storm, about 400 to 450 miles from its center. The minimum sea-level pressure at the Chicago station, about 12 miles from the path of the Melrose Park–Wilmette tornado, was 29.10 inches at about 12:55 p. m., while at the home of the writer, situated about 5 miles from the path, it fell suddenly 0.15 inch to 29.03 inches, then rose abruptly 0.10 inch.

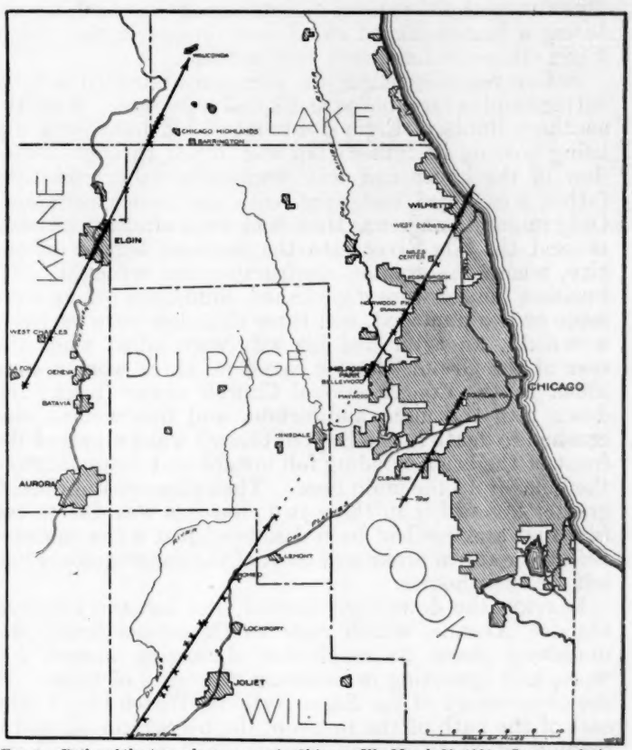


FIG. 1.—Paths of the tornadoes near or in Chicago, Ill., March 28, 1920. Cross-marks indicate points where damage was observed or reported.

The following maximum wind velocities which were registered during the day show how widespread and

severe the storm was. Chicago, 43; Minneapolis, Minn., St. Joseph and Springfield, Mo., 44; Green Bay, Wis., and Concordia, Kans., 46; Duluth, Minn., Keokuk, Iowa, Cairo, Ill., and Evansville, Ind., 48; Wichita, Kans., Kansas City, Mo., Sioux City, Ia., and Grand Haven, Mich., 52; Omaha, Nebr., and Indianapolis, Ind., 56; and St. Louis, Mo., 68 miles an hour. At Chicago the 24-hour wind movement, midnight to midnight, was 604 miles, and from noon to 2 p. m. it averaged 32 miles an hour. The strong wind, which was from the southwest at the lower cloud level, carried the tornado clouds along, practically without deviation, in a northeasterly direction. It is interesting to note that the path of the Melrose Park–Wilmette tornado, which is 50 miles in length, shows a slight curvature, due, probably, to some extent at least, to the gyratory motion of the air around the storm center.

The Elgin tornado apparently had its inception in Kane County about 3½ miles southwest of Geneva and 1½ miles southeast of the village of Lafox at about 12:05 p. m. It moved directly northeastward to Elgin, where it passed through the business center of the city and out Dundee Avenue and the Dundee road. It then moved across the extreme northwestern part of Cook County into Lake County, continuing due northeast to the village of Wauconda, beyond which no reports of damage have been received. The tornado passed one-half mile east of the St. Charles School for Boys at 12:10 p. m., and reached Elgin, 15 miles from its point of inception at 12:23 p. m., or at an average velocity of translation of 50 miles an hour. The total length of its path was approximately 30 miles and its width varied from 300 yards to about one-half mile. Eyewitnesses at various points along its path report seeing a funnel-shaped cloud, but no one in the city of Elgin claims to have seen such a cloud.

Before reaching Elgin the tornado destroyed a farm cottage and several barns and killed four cows. Near the southern limits of Elgin a 4-months' old baby who was being held on its father's lap was hurled through a window of the house and was practically unhurt, but the father was killed instantly when the house collapsed. Only minor damage was then done until after the tornado crossed the Fox River into the business section of the city, where the greatest destruction was wrought. Six business houses were demolished, numerous others were more or less damaged, and three churches were partially wrecked. An actor and his wife were killed when the rear of the Grand Theater caved in, three women were killed as the Congregational Church tower (brick) fell down into the main auditorium, and one woman was crushed to death in the Baptist Church when a part of the front of the brick building fell inward and down through the balcony to the main floor. That there was not much greater loss of life in these two churches was due to the fact that services had been dismissed just a few minutes before the storm broke and most of the congregations had left for their homes.

Leaving the downtown district, the tornado followed Dundee Avenue, which runs southwest-northeast, demolishing about 25 residences, damaging almost 200 more, and uprooting or breaking off scores of trees. At the observatory of the Elgin National Watch Co., 1 mile east of the path of the tornado, the barograph showed a reading of 28.40 inches (about 29.10 inches sea-level pressure) with a sudden decrease of only 0.08 inch.* The wind, which had been blowing steadily from the southeast at the rate of about 20 miles an hour, suddenly shifted to the southwest at 12.23 p. m., and a maximum velocity of 30 miles an hour was registered with an extreme velocity of 44 miles an hour. The Elgin Daily News describes the tornado as follows:

> A violent hailstorm preceded the blast, followed almost immediately by high winds, increasing in velocity. Sudden darkness, a roar, and an atmosphere of flying débris foretold the possible extent of destruction.

Immediately northeast of Elgin, on the Dundee road, many trees were uprooted or broken off and were left lying to the northeast, north, or northwest. Farther to the northeast the funnel-shaped cloud apparently lifted, descending only at intervals thereafter. The barns at the Bosworth and Logel farms, 3 and 4½ miles, respectively, from Elgin, were totally destroyed; 10 cattle were killed at the former and 28 at the latter place. About 10 to 12 miles northeast of Elgin and about 4 miles west of Barrington considerable damage was done to farm buildings. The postmaster at the village of Wauconda reports that a funnel-shaped cloud was seen there. The damage sustained in Wauconda and vicinity was about $30,000, several cattle being killed and many buildings demolished. The Elgin tornado, in its entire path of 30 miles, caused the death of 8 persons, injured about 100 others, and destroyed at least $1,000,000 worth of property.

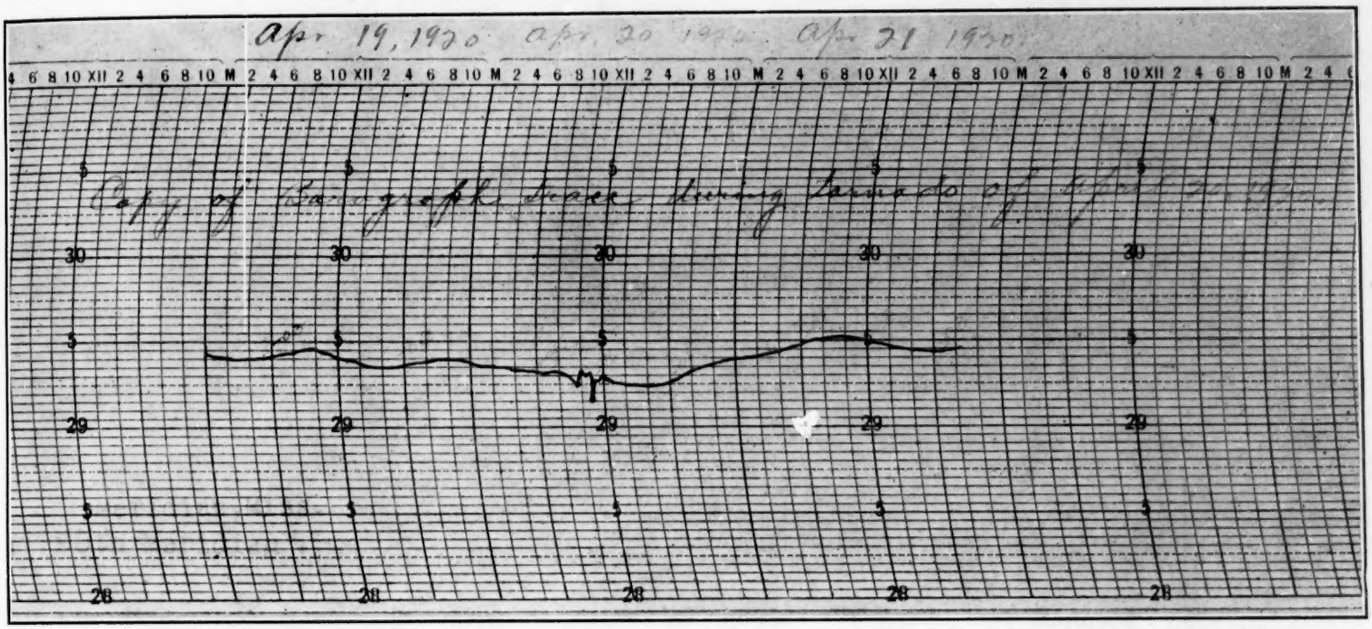
The Melrose Park-Wilmette tornado originated about 12.15 p. m. in Will County, 1½ miles north of the village of Channahon and 8 miles southwest of Joliet. The funnel-shaped tornado cloud was first seen and damage was first noted at the farm of John Dixon, near the Illinois and Michigan Canal, where the barn was wrecked, the roof being carried 500 feet. Immediately to the northeast, at a gravel pit, a 90-foot chimney was razed and many large oak trees were uprooted, all falling in a northeasterly direction. The tornado, with its funnel-shaped cloud, rising and dipping at intervals, moved rapidly northeastward across Channahon, Troy, and Lockport townships, injuring 17 people, some of them seriously, demolishing 5 houses, 2 frame school buildings, at least a dozen barns, and damaging several other houses and barns, with a total monetary loss of about $500,000.

The greatest destruction was wrought about 3 miles west and northwest of Joliet in the vicinity of the Black road and Six Corners. It was here that the 17 persons were injured when their homes were totally wrecked, and most of the farm buildings were demolished in a half-mile path. The tornado was especially violent at the Frank Siegel farm. The house was totally destroyed, the débris being scattered to the southeast and south for a distance of 25 to 75 feet. The family, consisting of father, mother, nine children, and a relative, saw the tornado approaching and endeavored to get to the cellar through the kitchen. However, the house was torn asunder before they reached the cellar stairs, and all, accompanied by a heavy range and the kitchen furniture, were carried 125 feet to the northeast and deposited near a large corn crib which, although directly in the storm's path, was practically undamaged. All members of the family were injured, several seriously.

The tornado cloud lifted when about 2½ miles northwest of Lockport and it dipped only occasionally as it neared the Des Plaines River and the damage was slight in the Romeo section. After leaving the river, the funnel-shaped cloud was not seen and only minor damage was done until the tornado reached Bellwood and Maywood, about 5 miles west of the western limits of Chicago. In Bellwood and Maywood, which join Melrose Park on

*Compare J. H. J. fig. 2, opposite.

To face p. 192.]



J. H. J. FIG. 2.—Barograph trace during the tornado of April 20, at Meridian, Miss. (Tornado passed about a mile from the station.) (See p. 203.)

FIG. 2.—House of Augusta Kruse, Melrose Park, Ill. (Courtesy of Mr. Jun Fujita, Chicago Evening Post.)

FIG. 3.—Ruins of the Sacred Heart Convent, looking northeast across Fourteenth Avenue, Melrose Park, Ill. (Courtesy of Mr. Jun Fujita Chicago Evening Post.)

the south, 4 lives were lost, 3 persons were injured and about 20 houses were demolished.

The greatest devastation and loss of life was experienced in Melrose Park, where 10 people were killed, 49 injured, about 50 houses, 1 church, and 1 convent demolished, a large brick school building badly wrecked, and numerous houses were more or less damaged. Entering the village in the vicinity of Lake and Twenty-first Streets at about 12:55 p.m., the tornado cut a path northeastward about 100 yards wide, leaving the northern limits at Division and Thirteenth Streets. The Sacred Heart Church was demolished, the church bell, weighing a ton, was carried 100 feet away, and the convent attached to the church was reduced to a mass of ruins. (See figs. 2 and 3.)

The tornado continued to move directly northeastward to Lake Michigan, a distance of about 17 miles from the southern limits of Melrose Park, passing through Leyden township, Dunning, Norwood Park, the extreme northwestern part of Chicago, Niles township, northwestern Evanston,* and across Wilmette to the Lake, which it reached about 1:15 p.m. Much of this region, outside of Wilmette and Evanston, is open country, where the damage was not so great. However, 6 people were killed in Dunning and about 18 were injured in Wilmette. In the latter town the path of the tornado was about two blocks wide. Two churches and many houses were damaged and scores of trees were uprooted. Only a few persons between Melrose Park and Wilmette reported seeing the funnel-shaped cloud. In one hour the tornado moved from its point of inception in Will County to Lake Michigan at Wilmette, a distance of 50 miles. The statistics for the entire 50-mile path are as follows: Lives lost, 20; number injured, about 300; houses demolished, 113; houses partially wrecked, nearly 300; loss to buildings and personal property, at least $2,000,000.

The path of the Clearing tornado was 10 miles in length, the first damage reported being at West Seventy-ninth Street and Harlem Avenue, at about 1 p.m., and the last on Lexington Avenue just west of South Francisco Avenue, less than 4 miles west-southwest of the Loop District of Chicago, at 1:15 p.m., or slightly later. In the main the damage was confined to unroofed houses, toppled chimneys and broken windows in a path about 100 yards wide. However, in the Clearing section five houses in a row were wrecked on South McVicker Avenue, near West Sixty-first Street, and a home and a portable school building near West Fifty-fifth Street and South Central Avenue were demolished. A funnel-shaped cloud was seen here, but at no other place along the tornado's path. An eyewitness of the approaching storm at West Twenty-sixth Street and South Avers Avenue describes the clouds as being black, low, very turbulent, and rolling. No lives were lost in this tornado, but 6 people were slightly injured, 7 houses and 1 school building were wrecked, and there was a property loss of about $150,000.

In addition to the three tornadoes described in detail, the cooperative observer at Sycamore, DeKalb County, about 15 miles west of the path of the Elgin tornado, writes as follows:

> We had a tornado on Sunday, March 28. A hailstorm that was very bad set in after the tornado. There were several barns, silos, and windmills blown down and telegraph and telephone lines are down. The rural districts east of town suffered the most, the amount of damage sustained being about $25,000. A funnel-shaped cloud was seen and the path of destruction was about 300 feet wide.

This may have been the same storm that passed into Walworth County, Wisconsin.

IN WISCONSIN.

Walworth County.—During the severe windstorm of March 28, 1920, at about 12:30 p. m., a small tornado passed from south to north through the eastern part of Walworth County, Wis. It passed about 4 miles east of Elkhorn, 2½ miles west of Spring Prairie, and 2 miles west of East Troy, where apparently it disappeared.

A funnel-shaped cloud and other tornado characteristics are said to have accompanied the storm. The path of greatest destruction was variously reported as from 20 to 40 rods wide. It evidently was short, as careful inquiry fails to discover it in any other section. There appears to be an opinion that it came north from Elgin, Ill., but I can find no trace of tornado characteristics along the Wisconsin-Illinois boundary. A map showing the probable path is attached. (See fig. 4.)

One woman was killed. Also, several head of live stock were killed, and several barns and many outbuildings and fences were destroyed. The property loss has been estimated at $25,000.—*W. P. Stewart, Milwaukee.*

IN INDIANA.

Allen County.—The weather at Fort Wayne, Ind., did not differ materially from the conditions that usually attend a distribution of pressure such as that which existed on the morning and night of March 28. It was rather pleasant during the midday hours, but thunderstorms, attended by light showers, occurred between the hours of 9:35 a. m. and 9:45 a. m. and between 4:58 p. m. and 5:50 p. m. The weather was unusually threatening from 5 p. m. to 6 p. m., and nimbus clouds moving rapidly from the southwest hung quite low. Moderate south to southwest winds prevailed during the afternoon and night, with greatest velocity, 38 miles, from the south, at 4:11 p. m. The lowest sea-level pressure, 29.17 inches, occurred at 5:15 p. m.

In the eastern part of Allen County, Ind., the weather became decidedly threatening the evening of the 28th, and a destructive storm entered the county from the southwest, passing between Hoagland and Monroeville and moving in an irregular path to the northeast. It passed out of the county and State at Edgerton, Ind., 19 miles to the eastward of Fort Wayne, leaving a trail of death and destruction. The storm is reported to have entered Allen County about 5:30 p. m. and to have passed out of the county at Edgerton at 6 p. m. It is said to have had a funnel-shaped cloud and rotary winds, and the position of fallen trees and timbers blown from demolished buildings attest to the truth of these reports. The path of the storm was about a half a mile to a mile wide, but it covered a sparsely settled area, Edgerton, with a population of about 200, being the most populous place in the storm's path. The farming element suffered the greatest loss in the way of damaged or demolished houses, barns, outhouses, and fences. The hamlet of Townley, which consisted of several houses, a store, a church, and an elevator, was completely wiped out and the timbers of the destroyed buildings were scattered over the adjacent fields. The town of Edgerton was badly damaged, but no lives were lost in that place. The fields along the storm's path were literally covered with timbers from demolished structures. Trees were uprooted or twisted off and lay in all directions. In all there were probably 100 houses, barns, or

* One peculiar freak of tornado action was the tearing apart of an automobile engine (cf. photo in "*Illustrated World*," June, 1920, p. 638).—ED.

outhouses either badly damaged or wiped out, entailing a loss estimated at about $1,000,000. There were 13 lives lost and 34 persons injured.—*P. McDonough, Fort Wayne, Ind.*

Jay and Adams Counties.—The tornado which swept over a part of Jay and Adams Counties—one of three* such storms occurring in northeastern Indiana in the late afternoon of March 28, 1920—first touched the surface southwest of West Liberty, a small village in northeastern Jay County, and is reported to have continued in unbroken contact with the earth for a distance of about 40 miles, passing into Ohio east of Berne, Ind. Considerable loss of life occurred, many were severely injured, and nearly all improvements in the path of the storm were destroyed. The time of occurrence of this particular tornado, shortly after 6 p. m., was somewhat later than the other Indiana storms of this date, and consequently the loss of life was greater, for it was becoming dark, partly due to dense clouds, when the storm struck and many people not realizing that a tornado was approaching took no precautions. Fortunately, the course through Indiana was confined to a strictly rural section, there being only one small village, that of West Liberty, in its path.

The path of devastation east of Berne which was visited by the writer appeared to vary considerably in width, although it was difficult to judge owing to the distance between the houses laterally. At one point two sets of buildings at right angles to the path about ¼ of a mile apart were almost entirely destroyed, while the width of partial damage at this place was nearly a mile wide, but at another place a few miles away buildings less than ¼ of a mile from the center of action were undisturbed. A majority of the buildings in this district within the sweep of the storm were totally wrecked, and in many cases they were broken into kindling wood and scattered over the near-by countryside. As a rule, one wall of a house could be found and that invariably was lying a short distance to the right of its former position, although some houses were so badly demolished that only the floor could be distinguished and it had been moved some distance. There was more débris to the right than to the left of the center of the path. Haystacks were, as a rule, still standing. Chickens were observed which had been entirely stripped of feathers on one side of the body only. Trees in some cases were broken off a short distance above the ground, but a number of trees had been twisted rather than broken and the base of the tree was shredded. Fence posts were plastered with mud and straw on all sides, and a sheet of galvanized iron that had lodged in a tree was punctured in many places by small pieces of wood which were still in the iron. There were indications of a circular movement, but, due to the destruction being so complete, it was not pronounced as indicated by the direction in which the wreckage lay, although it could be seen that trees had been twisted counterclockwise. Several people who were in or near the storm stated that it was too dark to distinguish the funnel-shaped cloud, but that it appeared to them as a large cloud of smoke approaching. However, many people saw the funnel-shaped cloud from a distance. A number of people spoke of the loud roaring noise attending the storm, and this was heard in Berne, 5 miles away.—*E. W. Holcomb, Indianapolis.*

IN OHIO.

The two tornadoes which were reported to have crossed the State line from Indiana into Ohio are doubtless responsible for the damage and loss of life at Nashville, Greenville, Lima, Van Wert, and other towns west and southwest of Toledo. The reports are indefinite, however, and the Weather Bureau observer at Toledo states that there is no authentic record of the funnel-shaped cloud in the immediate vicinity of that place. The total number of deaths reported was 31.

IN LOWER MICHIGAN.

St. Joseph to Gratiot Counties.—During the late afternoon of March 28, 1920, a tornado originated in southwestern Michigan, apparently in the northwestern part of St. Joseph County, and traveled in a northeasterly course for a distance of 100 miles or more. For the most part the path was through farming districts, but it passed through St. Johns, Mich., a town of about 5,000 inhabitants, and several small settlements, including Wacousta and Eureka.

The storm struck St. Johns at 5:08 p.m., 90th meridian time. Those who passed through the storm noted the funnel-shaped cloud, the terrific noise, and other characteristics of a typical tornado. An examination of the débris also revealed the true nature of the storm, as it was distributed in a manner which proved the revolving motion of the winds, some things being carried to the right and others to the left. Many buildings showed the explosive effect, as window glass in many cases was blown outward toward the center of the path, roofs were removed, and the whole sides of several buildings, including a substantial brick factory, were torn away as if by a charge of explosive.

A drenching rain fell after the storm had passed, but no hail was reported in the immediate path. Hail fell in Lansing and at several other points some distance away from the storm, and the hailstones which fell at some points were unusually large, notably near Mason, Mich., about 20 miles east of the path, where they were reported to be as much as 6 inches in circumference.

The width of the path as it passed over St. Johns, Mich., was about 300 feet. No data are available as to width of path at other points.

The property damage in St. Johns and vicinity probably exceeds $250,000, but there was no loss of life or serious personal injury in that locality, largely accounted for by the fact that the storm occurred on Sunday, when the factories and store buildings, which were demolished, were deserted. Press dispatches mention three deaths near Maple Grove, a few miles north of Battle Creek, Mich.—*D. A. Seeley, Lansing.*

Saginaw County.—Sunday, March 28, about 6:30 p. m., a tornado swept a path about 3½ miles through Saginaw County, on the western outskirts of the city of Saginaw. Fortunately, it passed over a thinly populated district. Four farms were damaged, but no one was hurt. The monetary loss is estimated at about $20,000.

The funnel cloud first appeared a mile south of Brockway Street, toppling over several telegraph poles. Then moving a little north of northeast it did not touch the earth until it reached John Dirker's farm, where it cut a path about a hundred feet wide between the main barn and dwelling house. On its southern edge it took off the western chimney of the house, sucked off the shingles and rafters from an outhouse, tilted the ice house forward, and wrecked the apple orchard in front of it. Telegraph and telephone poles, fences, and piles of corn stalks were swept away. Evidently the funnel-shaped cloud came down earthward in such a way as to miss the

* Details concerning only two have been received.—ED.

barn and dwelling, but in time to wreck what was in front. The apple trees in the center of the path were bent or snapped northeastward, but on the edges of the path they were twisted in clockwise direction. As one stood in the path of the storm facing northeast, the direction in which it moved, the trees in the center of the path were blown over toward the northeast, or in the direction of the forward movement of the tornado. Along the right side of the path there were trees standing that had branches farthest from the storm's center twisted backward and inward around the trunk, while the outer branches of trees on the left of the path were twisted forward and inward.

Across Brockway Street on another farm the tornado cut away the southern third of the main barn and took away the southern half of a chicken house, leaving the north half with setting hens untouched. It also blew down the apple orchard here, and the two chimneys on the dwelling house, on the southern edge of its path. It then ascended for half a mile, passing over a tall grove of elms, only tearing off one large branch. But in the bark of these trees were found straws and pieces of wood embedded as much as half an inch.

Hemmeter's barn, a strong building, 95 by 40 feet, lay in a slight hollow northeast of the grove of trees. Here the tornado passed directly over it on one of its low swoops. The barn blew outward and upward, not a single board or beam being left intact. The wreckage showed this clearly, and Alors Franc, a farmer, saw it happen. The débris was scattered for a mile in a clearly defined path from 100 to 150 feet wide, and the rotary action had laid it not unlike a magnetic field. Huge beams and sections of the roof were found more than one-half mile from the site of the barn, embedded in the soil as much as 5 feet. The free ends all tilted inward and backward toward the place of action.

Alors Franc saw the funnel-shaped cloud when it first appeared and watched it as it came straight for his farm. He described the general clouds as black, and the funnel like a gray trousers leg, which rose and fell, and swayed from side to side, was once or twice near the ground, especially when it passed over Hemmeter's barn. The débris was seen to rotate around the funnel like a summer dust squall on a large scale.

Coming directly toward the Alors Franc farm it took a sharp turn eastward, missing the house by only a few yards and doing no damage except that the main barn door was driven inward, breaking the heavy wooden beam which fastened it. The tornado picked up an iron bridge across the ditch, beside the road, and slammed it against the barn on the farm across the street. The farm belonging to Frank Mrakva across Mackinaw Street lay right in the way, and suffered considerably. The tornado cut a third of his barn away as clearly as if a saw had cut it out, tore off the chimneys on the dwelling house on the southern side of the whirl, wrecked an outhouse and the apple orchard. The débris from the barn was scattered for a quarter of a mile. On Court Street, a little farther northeast, it apparently had gone up or weakened, for it only blew the windows out of one house, and on State Street it picked up an automobile from the street and set it in the ditch.

The funnel cloud was not seen by John Dirker, owner of the first farm visited by the whirl, but he described the noise as being like a hundred express trains passing by in an instant. Alors Franc, who saw the funnel-shaped cloud from the first, said it sounded to him like a lot of water going over rocks. Both witnesses said there had been rain, hail, thunder, and lightning, just before the tornado came, but at the time of its passage these had ceased. After the tornado had passed the wind was light.—*Robert M. Dole, Saginaw.*

Shiawassee County.—The first observed path of this tornado was on a small knoll 100 yards to the southwest of the farmhouse of A. W. Higbee, about 3½ miles south-southeast of Perry, Mich. A newspaper report that a touch of the storm was felt near Mason, Mich., some 12 to 15 miles southwest of the first observed effects of the storm, has not been corroborated.

The first effects were among a few small fruit trees on the summit of the knoll, from which point the storm tore many shingles off the two main barns on the farm, and demolished the tool barn, all being within a few yards of each other, and between the fruit trees and the house. The house itself was of two parts, an older square, colonial style of heavy-beamed construction, and a newer part of "balloon framing." The new part was an almost total wreck, unroofed, walls bulging, and superstructure gone. The old part withstood the storm remarkably, although severely strained, and with a part of the west wall crushed in by the flying roof from the kitchen porch. This fracture of the wall by the porch roof was so severe as to ruin a bedstead standing against the wall inside.

Several large, beautiful trees standing in front of the house were broken short off at about the height of the main part of the house, a circumstance that gives some strength to the theory that a slight dip in the knoll on the side of which the house stood probably saved the house from complete destruction.

Eyewitnesses here described the storm as coming on suddenly, although there had been rain and thunder for some little time. The first impressions were described as of a very severe hailstorm, with a terrible roaring, inky blackness, and driving rain and hail. This description was corroborated by all who experienced the storm, a terrible driving force, inky blackness, a deluge of rain with driving hail, for just the few moments it took the storm to pass, after which it "was all over," and the normal thundershower conditions again prevailed. Those at one side of the path describe the funnel-shaped tornado cloud in detail.

From the Higbee farm the path of the storm was due northeast for about 2½ to 3 miles; thence turning to the east-northeast, later again turning to the northeast. The total length of the path was about 8 miles, fortunately mostly through open fields, but altogether through a prosperous farming country.

Across the road from the Higbee farm, on the farm of Harry Bridger, a small grove near the house was ruined, though the house being a few feet to one side of the path, was hardly touched. Two barns here were complete ruins, one being crumpled together like a pasteboard box, the other, the main barn, being scattered all over a 160-acre field, with only the iron stanchions left standing. A rafter of this barn was used by the observer to cross a ditch a quarter of a mile from the barn site.

A half mile farther on the storm cut diagonally through a woods lot, cutting a clean swath. The larger trees seemed to suffer even more than the smaller ones, although not a single unbroken trunk was left in the path. In this woods lot the true tornadic action was very evident, those trees which were not uprooted being twisted or broken off. On the southeast side of the storm track the twisting action seemed to have been from right to left, and the trunks were lying mostly pointing slightly inward toward the center of the track. On the northwest

side of the track, however, these conditions were reversed, the twisting action seeming to have been from left to right, and all fallen trunks were lying pronouncedly diagonally inward toward the center. The wreckage in the woods lots visited was almost impassable.

A half mile from this first woods lot the storm cut through another, where the same effects were observed. It was in this second woods, however, that in several instances small, tough branches were observed twisted around the upstanding stumps from left to right; that is, from west around through north to east. These branches were in some instances 2 or more inches thick, furnishing unmistakable evidence of the tornadic action.

Beyond this point the path of the storm for some distance was across open fields, though one orchard was observed to be nearly ruined. Farther on, it was reported, several more barns were demolished. The last report of the storm was about midway between Morrice and Bancroft, Mich.

At no point observed did the width of the path of destruction exceed approximately 100 yards, often being as narrow as 75 yards. The time of occurrence could not be determined within about 15 minutes, all who observed the storm stating that it came "between 5:30 and 6" in the afternoon, the sum of opinions being about 5:40 to 5:45 p. m.

Fortunately, no lives were lost, nor was any one seriously hurt, and very little live stock, the observer hearing of one cow, two sheep, and one hog definitely lost, and a report not yet confirmed that several more sheep were lost on one farm.

No traces of the storm beyond 4 miles northeast of Morrice could be obtained, and the storm probably did not strike the ground again.—*B. B. Whittier, Lansing.*

Oakland County.—There is little definite information reported concerning the Oakland County tornado. The cities of Fenton and Flint reported serious damage from wind storms. The path as marked on the map (fig. 4) is that reported by the observer at Lansing. Four deaths were reported at Fenton.

IN CENTRAL ILLINOIS.

Logan County.—A tornado occurred in Logan County between 5 and 5:30 p. m. It had its origin near the Sangamon County line, west of Cornland, moved north by 30° east to a point near Broadwell, thence due north, passing just west of Lincoln, and dissipating a few miles north of that city. (See fig. 4.) Its path was about 20 miles long. It seemed to rise when it reached the west boundary of Lincoln and at other places in its path, leaving some places unharmed. Several farm residences were damaged, and there was considrable loss or damage to trees, electric wires and poles, and to barns and other farm buildings. Several head of cattle were killed. The property loss is estimated at $15,000. Four persons were reported injured.—*Clarence J. Root, Springfield, Ill.*

DISCUSSION OF TORNADO CONDITIONS.

The weather conditions which produced 11 tornadoes in the States bordering on Lake Michigan, and at least two in Alabama and Georgia, are well worthy of study.

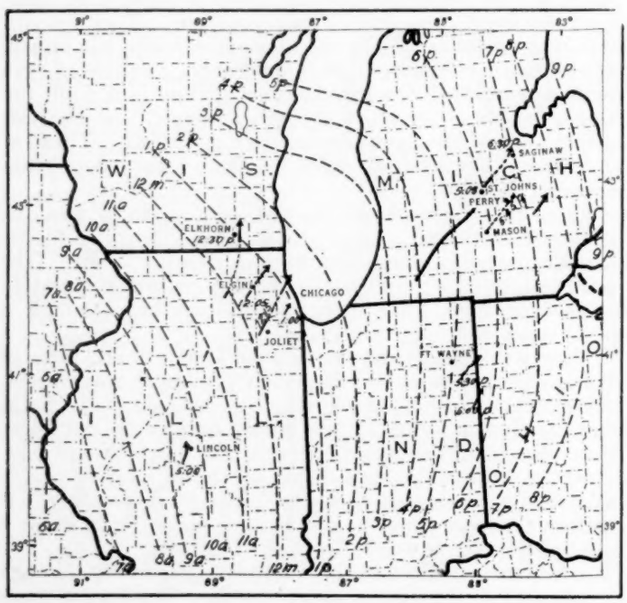


FIG. 4.—Tornadoes in the vicinity of Lake Michigan, March 28, 1920, and the hourly advance of the squall line. (A third tornado was reported in Indiana but its location not mentioned.)

With respect to lower Michigan in which three of the tornadoes appeared, Mr. B. B. Whittier, of the U. S. Weather Bureau at Lansing, made an interesting study of the time of passage the squall line and lines of first thunder and beginning of rainfall, in connection with the occurrence of tornadoes. In order to investigate the entire region in which the northern group of tornadoes occurred, his plan has been extended to cover the territory between Iowa and Ohio. Figure 4 shows the area in which the tornadoes occurred with their various paths and with hourly positions of the squall line as it progressed from west to east. These data have been obtained from the original instrumental records of the stations concerned. At many stations, especially those in the southern part of the region, the time of squall-line passage is difficult to determine from the records.

Appearing at 6 a. m. in eastern Iowa, a line of wind convergence advanced on a slightly curved front in a general east-northeasterly direction, reaching the vicinity of Chicago at about 12:30 o'clock. As the squall on this line crossed the Lake, the lesser friction of the water surface enabled the line to advance with increased speed thus creating a forward bulge in this part of the line. (See fig. 4.) In Indiana, this wind front was not so well marked. The last appearance of the squall within the region of the map was at 9:30 p. m. at Port Huron, Mich. Figure 5 shows the wind directions and speeds at various stations as the squall progressed across the region.

The line of first thunder as shown by Mr. Whittier occupied five hours in crossing Michigan, appearing on the east shore of Lake Michigan at 3 p. m. and leaving the State at about 8 p. m. First rain followed thunder half hour later across the State, but the rains were not so general.

A clearer idea of the weather on the day in question in the tornado region can be obtained from a study of the actual weather at a few places. Springfield, Ill., and Grand Rapids, Mich., afford good examples: At Springfield the day began with an overcast sky, with rain during the early morning hours, and a little hail which fell for about two minutes about 4 a. m. But

there was a rapid clearing so that by 7 a. m. the sky was clear. The wind was from the south-southeast at 8 a. m., became south by 8:30 and continued so until about 10, when there was an abrupt change to southwest. While the velocity in the early morning hours was higher than usual, there was a decided increase from 25 to 37 miles per hour in the wind about a half hour before the wind shift. Immediately after the wind shift, the speed of the wind reached 40 miles per hour. This wind did not drop below 30 miles per hour all day, and reached a maximum for the day of 41 miles per

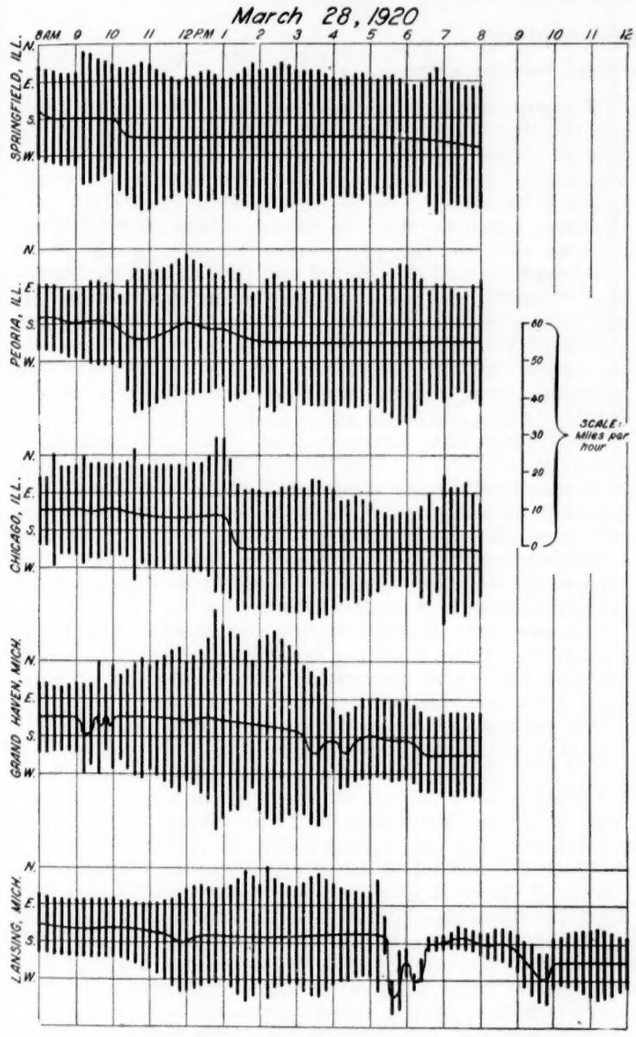


FIG. 5.—Wind velocity and direction at various stations, March 28, 1920.

hour at 6:30 p. m. About 5 p. m., the wind, which had been steady southwest since morning, began a slow change toward west. The nearest tornado occurred at Lincoln, Ill., about 30 miles northeast of Springfield, at 5:30 p. m. An interesting and striking feature of the squall-line passage was the presence in its rear of a region of extremely low relative humidity. The reading taken at noon at Springfield was 16 per cent, the lowest ever recorded at that station. The morning and evening observations gave relative humidities of 76 and 48 per cent, respectively. As pointed out by Mr. P. C. Day in the March REVIEW (**48:** 172), there was a belt of extremely low humidity extending from eastern Missouri northward over central Illinois, which was probably caused by the descent of rain-dried air, foehn-like, from nigh altitudes immediately in the rear of the line of wind convergence which gave rise to the tornadoes.

At Grand Rapids, on the contrary, the wind speed during the day was not very high, being for the greater part below 20 miles per hour between 12 and 2 p. m. Until about 4 p. m., the wind was south-southeast, but at that time it became variable between southwest, south-southwest, and south, and about 6.15 more steady southwest. Between 4 and 4.30 p. m., there was a shower, in which 0.37 inch of rain fell. The morning observation showed a total sky cover of cirro-stratus moving from

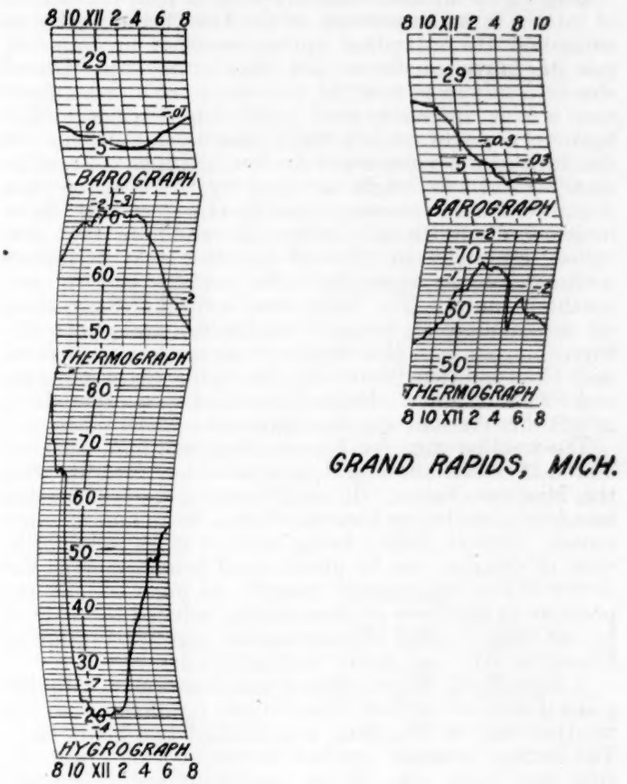


FIG. 6.—Traces of recording instruments at Springfield, Ill., and Grand Rapids, Mich., March 28, 1920.

the west. By noon, there had appeared a layer of stratocumulus which covered eight-tenths of the sky. These clouds moved from the southeast. At the time of evening observation, after the tornadoes had occurred in that region, the sky was perfectly clear, a condition suggestive of descending air similar to that noted in Illinois. The humidity did not show a marked change such as was noted at Springfield, although one can not make this statement without reservation since the Grand Rapids station does not maintain a hygrograph which would afford a continuous record. At 7 a. m., noon, and 7 p. m., observations of relative humidity gave 56, 58, and 61 per cent, respectively. The temperature rose steadily all morning, reaching a maximum of 69° at 1.30. About

the time of the shower, however, (and this may be said to mark the passage of the squall line,) there was a very sudden drop from 65° to 56° and a somewhat slower rise to 63° by 5.15, followed by an irregular drop to 56° at 8 p. m.

Figure 6, giving the copies of the original records from Springfield and Grand Rapids, shows the progress of meteorological phenomena during the day. It appears from the examination of many records, even from those much closer to the paths of the tornadoes than these, that there is very little disturbance to the diurnal march of the elements upon the passage of these very violent disturbances up to within a very short distance from the whirl. This simply emphasizes the extremely local character of the tornado, and is borne out by the seemingly capricious conduct of the whirling cloud as it passes along. As is seen from the figure there was little or no barometric disturbance at the time of tornado passage, although severe tornadoes passed only a few miles from the station.—*C. LeRoy Meisinger.*

A KITE FLIGHT IN THE CENTER OF A DEEP AREA OF LOW PRESSURE.

By VINCENT E. JAKL, Meteorologist.

[Weather Bureau Aerological Station, Drexel, Nebr., May 24, 1920.]

Kite flights are not ordinarily possible near the centers of intense LOWS on account of the kites being unable to withstand the attendant stormy weather or winds of gale to hurricane force. On March 28, 1920, Drexel was evidently in or near the very center of a well-defined LOW of the circular or oval type. Light winds in this region of the LOW made a flight possible, but also limited the flight to a comparatively low altitude. Notwithstanding the low height attained by the kites on that day, the rather unusual circumstance of the flight invites a discussion of the free-air conditions that prevailed, especially in view of the fact that tornadoes occurred on the same day over middle eastern and southern States. The deductions arrived at, suggesting an explanation of tornado conditions, are principally from the results of this flight and a comparison of them with the conditions shown by the flights of the previous and following days. Related conditions on other dates or at other stations are also discussed or referred to.

The weather map for 7 a. m., 90th meridian time, on March 28, 1920, shows a deep area of low pressure over the Missouri Valley, the innermost isobar, 29 inches (sea-level), encircling Omaha, Nebr., as an approximate center. Drexel, Nebr., being only 18 miles west-northwest of Omaha, can be given equal prominence as the center of the low-pressure trough. In point of fact, the pressure at this hour of observation, reduced to sea level by the usual method of computation, was 28.94 inches at Drexel, or 0.04 inch lower than at Omaha.

A kite flight, begun almost simultaneously with the general 7 a. m. surface observations represented on the weather map of this date, was finished two hours later. The surface pressure reached its lowest level about the time the flight was begun, and remained practically stationary till about an hour after the flight was ended. The upper-air observations recorded during the flight can therefore be properly referred to the position of Drexel in the LOW indicated on the 7 a. m. weather map.

Light haze prevailed during the flight and until 11 a. m., or throughout the time the pressure remained low and stationary. Following the abrupt rise in pressure that began at 11 a. m., the haze gave place to stratocumulus clouds that quickly overcast the sky, and brought a fall of light rain, turning to snow. The surface wind, that had been light southerly during the flight, became a northwest gale shortly after the rise in pressure set in.

The significant facts that it is intended to bring out are the veering diminishing winds aloft during the progress of the flight, the apparent progressive veering of the winds from the highest altitude down to the ground, and the progressive fall in temperature at certain altitudes from the 27th to the end of the flight on the 28th.

The generally light diminishing winds encountered during the flight are undoubtedly a feature of the central area of a LOW, and can probably be explained as due to the gradual readjustment of the air masses to an almost opposite direction of movement. Some interesting conclusions, however, may be inferred from the apparent circumstance of the progressive veering of the wind downward toward the ground and the fall in temperature that attended and preceded the veering in direction. If the inference that the fall in temperature attending and preceding the veering in direction is carried farther, and an earlier fall in temperature in the higher altitudes assumed, some of the observed characteristics of the front of LOWS might be more easily explained.

A question that suggests itself from the records of the 27th and 28th is: Was the rapidly rising temperature in the strong southerly winds noted at and near the ground on the 27th, coincident with falling temperature at higher altitudes; and if so, was a similar but more pronounced condition a day later over sections farther to the east responsible for the tornadoes that were reported from middle eastern and southern States?

The first part of this question can be answered in the affirmative if the evidence is sufficient that the fall in temperature (with presumably no change in surface-wind direction, but with a change of 2 or 3 points at 1,500 meters) noted in the lower strata on the 28th began in the higher strata on the 27th. While it will be noted from Table 1 that much lower temperatures were recorded at all altitudes on the 28th as compared with corresponding altitudes on the 27th, there seems no reason to doubt, from the circumstance of pressure distribution, that the wind at these altitudes was blowing continuously from a southerly or southwesterly direction from the morning of the 27th to the morning of the 28th.

Owing to the strength of the winds aloft on the 27th, the flight on that day did not reach an altitude high enough nor cover a period of time long enough to show any marked changes in temperatures in the higher strata. A more complete kite flight was made on the same day at Royal Center, Ind., a record of which is given in Table 2. This record shows a small but distinct fall in temperature and increase in the lapse rate in the higher levels. However, more definite evidence of a simultaneous fall in temperature aloft and rising or sustained high temperature near the ground in the front quadrants of a LOW may be deduced from the records of some diurnal series of flights. Reference is made to the records of the diurnal series of October 16–17 and November 8–9, 1917 (1), both of which are good illustrations of progressive temperatures aloft preceding thunderstorm conditions. While these records apply to the autumn

season, they are fairly typical of the conditions in the front of a LOW leading to unstable equilibrium, and have been selected as the most descriptive of the records available.

Upper-air observations show conclusively that in the extratropical cyclone the isobars open up and become more or less V-shaped in the upper regions, and that the change from closed to open isobars varies in altitude according to the intensity, temperature distribution, and other characteristics of the storm. Assuming a circulation as depicted in figure 7, steep vertical temperature gradients and unstable equilibrium can be accounted for over the area receiving strong drainage of warm moist air from the Gulf. That colder air in the upper strata actually followed in the wake of the storm of March 28, is attested by the record of the kite flight of March 29. In this flight, the temperature recorded at 4,250 meters above sea level was as low as the midwinter mean for that altitude.(2) It is of further interest to note that this low temperature aloft occurred in an area of relative, not absolute, high pressure.

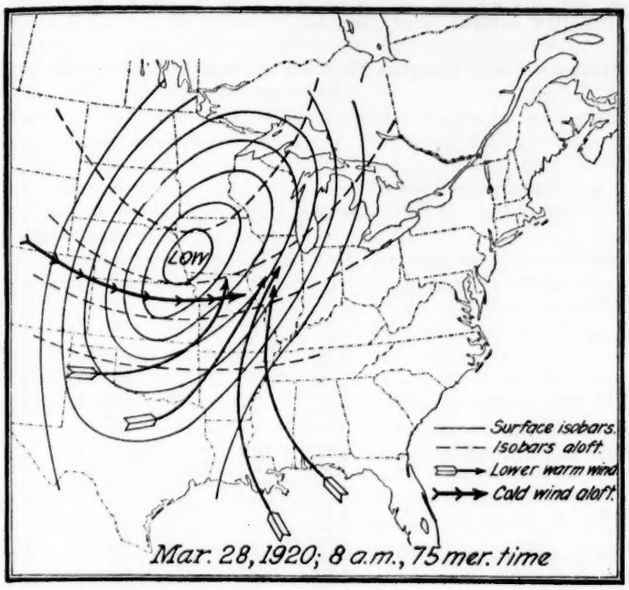


Fig. 7.—Wind flow in upper and lower levels of the LOW of March 28, 1920.

It is quite reasonable to suppose that the position of the V-shaped isobars aloft with reference to the center of low pressure on the surface varies with individual storms, and probably with the season for any average type of storm. A seasonal variation might account for the peculiarity of tornadoes to the spring and early summer months and the related fact of lag in the recovery of temperature aloft in spring. This lag is well shown for March and April over Drexel in figure 2, page 3, MONTHLY WEATHER REVIEW, January, 1920.(2)

In contrast to this sustained low temperature aloft is the occasional warm wave in strata near the ground, an example of which is shown in the temperature record of the flight of March 27. It is apparent from this record and from the subsequent further heating of the surface layers that in these lower strata temperatures finally occurred that were equal to or slightly exceeded the June averages.(2) The extreme contrast in temperature that occurred within less than 48 hours between the surface layers and those aloft was therefore nearly equal to the extreme annual range in their respective monthly averages.

Further statistical study of upper air observations in LOWS will probably show some average annual variation in the position of the isobars aloft with reference to those on the surface. A possible seasonal change that suggests itself from a cursory examination of kite flight records is that the apex or lower extremity of the isobars aloft may on the average be displaced eastward as the warm season advances. When flights are possible in the rear of pronounced circular or oval LOWS of the type of

TABLE 1.—*Free-air data from kite flights at Drexel, Nebr.*

Mar. 27, 1920.							Mar. 28, 1920.							Mar. 29, 1920.						
Time.	Surface temperature.	At different heights above sea.			Wind.		Time.	Surface temperature.	At different heights above sea.			Wind.		Time.	Surface temperature.	At different heights above sea.			Wind.	
		Altitude.	Temperature.	$\frac{\Delta t}{100\ m.}$	Direction.	Velocity.			Altitude.	Temperature.	$\frac{\Delta t}{100\ m.}$	Direction.	Velocity.			Altitude.	Temperature.	$\frac{\Delta t}{100\ m.}$	Direction.	Velocity.
A. M.	°C.	m.	°C.			m. p. s.	A. M.	°C.	m.	°C.			m. p. s.	A. M.	°C.	m.	°C.			m. p. s.
6:51	8.0	396	8.0	.....	sse.	8.0	7:38	6.6	396	6.6	.....	sse.	5.4	9:17	4.0	396	4.0	.....	ssw.	5.4
		500	8.6	.....	sse.	9.9			500	6.1	.....	sse.	7.4			500	3.7	.....	ssw.	5.0
		750	10.2	.....	s.	14.5			750	4.9	.....	s.	12.2	10:02	5.3	714	3.1	0.28	sw.	4.3
		1,000	11.8	.....	ssw.	19.0	7:46	6.6	825	4.5	0.49	s.	13.7			750	2.9	.....	sw.	4.7
7:03	8.0	1,088	12.3	−0.62	ssw.	20.6			1,000	3.3	.....	s.	12.0			1,000	1.6	.....	wsw.	7.5
		1,250	12.7	.....	ssw.	20.4			1,250	1.7	.....	ssw.	9.5			1,250	0.3	.....	w.	10.2
		1,500	13.3	.....	ssw.	20.0			1,500	0.0	.....	sw.	7.1	10:31	6.8	1,375	− 0.3	0.51	w.	11.6
7:17	8.4	1,602	13.6	−0.25	ssw.	19.9	8:30	7.6	1,581	−0.5	0.71	sw.	6.3			1,500	− 1.3	.....	w.	12.6
		2,000	10.3	.....	ssw.	19.0			1,500	0.1	.....	sw.	6.2			2,000	− 5.4	.....	w.	14.6
7:31	9.0	2,292	7.8	0.84	ssw.	18.4			1,250	2.0	.....	w.	6.1	10:46	7.3	2,069	− 6.0	0.82	w.	14.9
		2,500	4.9	.....	sw.	18.2	9:19	9.0	1,171	2.6	0.08	w.	6.0			2,500	− 7.7	.....	w.	15.0
7:42	9.4	2,841	2.8	0.85	sw.	17.9			1,000	2.7	.....	wsw.	6.0	10:58	8.3	2,782	− 8.8	0.39	w.	15.1
		2,500	5.5	.....	sw.	19.8	9:27	9.0	805	2.9	1.64	ssw.	6.1			3,000	− 9.7	.....	w.	15.1
		2,000	9.4	.....	sw.	22.6			750	3.7	.....	ssw.	6.0	11:11	8.0	3,364	−11.2	0.41	wnw.	15.2
7:55	10.1	1,602	12.6	0.80	sw.	24.9			500	7.6	.....	sw.	5.6			3,500	−12.0	.....	wnw.	15.7
		1,500	13.4	.....	sw.	23.8	9:31	9.2	396	9.2	.....	sw.	5.4			4,000	−15.1	.....	w.	17.5
		1,250	15.4	.....	sw.	21.0	.....	.....	.....	.....	.....	.....	.....	11:34	9.4	4,117	−15.8	0.61	w.	17.9
		1,000	17.4	.....	sw.	18.3	.....	.....	.....	.....	.....	.....	.....	11:44	9.6	4,252	−16.3	0.28	w.	17.9
9:37	15.4	974	17.6	−3.48	sw.	18.0	.....	.....	.....	.....	.....	.....	.....	P. M.		4,000	−15.8	.....	w.	17.6
9:46	15.7	793	11.3	1.21	ssw.	9.3	.....	.....	.....	.....	.....	.....	.....	12:15	10.6	3,965	−15.6	0.41	w.	17.4
		750	11.8	.....	ssw.	9.5	.....	.....	.....	.....	.....	.....	.....			3,500	−13.7	.....	w.	18.8
		500	14.8	.....	ssw.	10.3	.....	.....	.....	.....	.....	.....	.....	1:12	13.0	3,285	−12.8	0.63	w.	19.5
9:51	16.1	396	16.1	.....	ssw.	10.7	.....	.....	.....	.....	.....	.....	.....			3,000	−11.0	.....	w.	18.0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....			2,500	− 7.9	.....	wsw.	15.5
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1:34	13.7	2,427	− 7.4	0.96	wsw.	15.1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....			2,000	− 3.3	.....	wsw.	12.6
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1:45	13.8	1,874	− 2.1	0.92	wsw.	11.9
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....			1,500	1.4	.....	wsw.	12.0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2:03	13.2	1,247	3.7	1.05	wsw.	12.0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....			1,000	6.3	.....	wsw.	11.5
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2:18	13.1	830	8.1	1.29	wsw.	11.1
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....			750	9.1	.....	wsw.	11.0
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....			500	12.4	.....	wnw.	10.5
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2:25	13.7	396	13.7	.....	wnw.	10.3

March 28, they show a deep northerly or northwesterly wind, sometimes backing to westerly at still higher altitudes. On the other hand, flights in the rear of LOWS that seem more common to the winter season frequently show a strong, cold, more or less shallow northerly wind, surmounted by a wind from some southerly direction.

Thunderstorms occurred in the vicinity of Drexel on the night of the 27th–28th. The LOW had evidently been insufficiently developed to cause tornadoes in this section on the 27th, while by the 28th the conditions of temperature conducive to strong vertical circulation had passed by.

It is possible that when tornadoes occur near the center of a deep depression their cause is often largely mechanical and arises from a wind shift line much more abrupt than that apparent in the LOW of March 28.

REFERENCES.

(1) MONTHLY WEATHER REVIEW, SUPPLEMENT No. 11, Aerology No. 6, pages 63–66 and 76–80. See also MONTHLY WEATHER REVIEW, June, 1919, 47: fig. 5, p. 371.

(2) **W. R. Gregg.** Average free-air conditions as observed by means of kites at Drexel Aerological Station, Nebr., during the period November, 1915, to December, 1918, inclusive. MONTHLY WEATHER REVIEW, January, 1920, 48: 1–11.

DISCUSSION.

While there is no direct proof that there was a cold wind above the line where the tornadoes formed, it is reasonable to surmise its presence to account for the shift in surface wind. One other bit of evidence as to the presence of the cold wind above the warm is found in the occurrence of the tornado near Lincoln, Ill., late in the afternoon, about six hours after the passage of the wind-shift line that carried the other tornadoes. At Springfield, Ill., there was at this time a gradual change of wind to west, but it would not appear to have been sudden enough to account for a tornado without the aid of a strong vertical movement induced by a considerable contrast between the temperature of the wind near the surface, and that at a moderate elevation. In any event, the presence of a cold wind aloft may not be indispensable to the formation of tornadoes, where winds converge violently.—*Charles F. Brooks.*

TABLE 2.—*Free-air data from kite flights at Royal Center, Ind., Mar. 27, 1920.*

Time.	Surface temperature.	At different heights above sea.				
		Altitude.	Temperature.	$\frac{\Delta t}{100\ m.}$	Wind.	
					Direction.	Velocity.
A. M.	°C.	m.	°C.			m. p. s.
10:36	11.4	225	11.4		SE.	6.3
		250	11.1		SE.	6.2
		500	8.6		SE.	5.3
11:03	12.3	636	7.2	1.04	SE.	5.0
		750	7.6		SE.	5.8
		1,000	8.6		S.	7.4
		1,250	9.5		SSW.	9.1
11:53	14.8	1,314	9.8	−0.38	SSW.	9.5
		1,500	8.7		SSW.	10.8
		2,000	5.8		SW.	14.5
P. M.						
12:09	14.9	2,419	3.3	0.59	WSW.	17.5
		2,500	2.6		WSW.	17.4
		3,000	−1.5		WSW.	16.6
		3,500	−5.7		SW.	15.8
12:40	16.0	3,708	−7.4	0.73	SW.	15.5
		3,500	−6.1		SW.	15.3
		3,000	−3.0		SW.	14.7
1:05	16.5	2,537	−0.1	0.92	SW.	14.2
		2,500	0.3		SW.	14.3
		2,000	4.9		SW.	15.4
		1,500	9.5		SSW.	16.4
1:34	17.4	1,383	10.6	0.15	SSW.	16.7
		1,250	10.8		SSW.	15.8
		1,000	11.2		S.	14.0
		750	11.6		SSE.	12.2
1:54	17.5	605	11.8	1.53	SE.	11.2
		500	13.4		SE.	10.7
		250	17.2		SE.	9.5
2:00	17.6	225	17.6		SE.	9.4

THE TORNADOES OF MARCH 28, 1920, IN EAST-CENTRAL ALABAMA.

By P. H. SMYTH, Meteorologist.

[Weather Bureau, Montgomery, Ala., Apr. 24, 1920.]

The principal tornado first appeared at Deatesville, 18 miles north of Montgomery, and another at Cedar Springs, farther north. Unseasonably high temperatures prevailed during all the morning and afternoon of the 28th; at Montgomery the maximum was 77° F. at 11:45 a. m.; and at Wetumpka and Auburn the highest were 77° and 76°, respectively. The absolute humidity, as shown by the records at Montgomery, was likewise unseasonably high; the relative humidity at 7 a. m. was 91 per cent, at noon 74 per cent, and at 7 p. m. 79 per cent. Thunderstorms were reported from 10 stations in Alabama, most of these being in the east-central portion of the State. At Montgomery the average hourly wind velocity during the day was 14 miles, the directions varying from southeast to southwest.

THE DEATESVILLE-AGRICOLA-WEST POINT TORNADO.

This, the principal tornado in Alabama on the 28th, first appeared about 1 mile north of Deatesville, western Elmore County, near the Autauga-Elmore County line, at about 2:30 p. m. From Deatesville it moved east-northeastward over northern Elmore County, through south-central Tallapoosa County, wiping out the little village of Agricola, thence across southern Chambers County, crossing the Georgia-Alabama line at West Point, Ga., at about 3:37 p. m. The length of the track in Alabama, from Deatesville, Ala., to West Point, Ga., is about 65 miles on a straight line. Assuming the times as given above as correct, the speed of translation was about 60 miles per hour. As shown by a number of reports received, the tornado was well defined, from 100 yards to a quarter of a mile in diameter, marked by the usual funnel-shaped cloud, and accompanied by winds of very destructive violence.

Evidence of rotation was slight, amounting to the directions of felled trees at West Point, Ga., as reported by Conductor Hal Cline, of the Atlanta & West Point Railroad. He states that trees on the north side of the storm's path lay to the left; in the center, straight ahead; on the south side, to the right. Mr. Cline, while he did not see the funnel-shaped cloud, describes the clouds at West Point, Ga., just before the tornado struck, as follows:

> Coming to West Point about 3:30 p. m., I noticed awfully black, greenish-looking clouds; stood there about five minutes loading passengers. As we pulled out it began to rain a little; in about two minutes the storm hit us. We had to stop the train until it passed; came very near moving the train from the track. Of course, we were not directly in the path of the tornado, but on its edge. Being inside the cars and the rain so terrific, we did not look to notice the clouds.

Seventeen persons were killed in Alabama by the tornado; between 40 and 50 persons were injured, some of them seriously; and property, variously estimated at from $100,000 to $200,000 was destroyed. The greatest destruction was in Tallapoosa County in the vicinity of Susanna, Agricola, and the Red Ridge settlement. There is one reference to hail at Deatesville contained in newspaper reports. No reference to thunder is made in any of the reports received, but it is very likely that the tornado was accompanied by thunder and lightning, since thunderstorms were reported the same afternoon at Montgomery, Wetumpka, and Dadeville, points in close proximity to the storm's path. Numerous references are made in press reports to torrential rains in Tallapoosa County attending the tornado's passage. At Alexander City an estimated rainfall of 5 inches in one hour was reported. These reports are in part corroborated by the record of the rainfall station at Dadeville of 3.45 inches of rainfall from 11 a. m. to 10 p. m. Detailed reports from the section visited by the tornado follow:

Deatesville, western Elmore County.—Postmaster Ira C. Chapman reported as follows: The storm occurred about 1 mile north of Deatesville, thence eastward, about 2.30 p. m.; it came from the west and went toward the east; the funnel-shaped cloud was observed; trees in all sections of the path pointed eastward; width of path of greatest destruction about 100 yards; property loss closely estimated, $8,000; none killed; five injured.

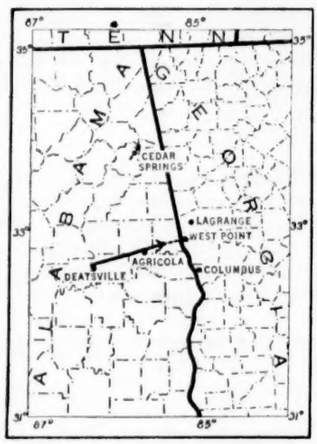


FIG. 10.—Tornadoes in Alabama and Georgia, March 28, 1920.

Eclectic, Elmore County.—Postmaster's report: The storm occurred about 3 p. m., coming from the northwest and going toward the southeast; the funnel-shaped cloud was observed; no appreciable damage was done at Eclectic, but it was heavier out 2 miles south and 4½ east of this place. The postmaster remarks: "The storm here was pretty heavy, but I could hardly tell you how it was. Came close to damaging some houses here. About 2 miles south of here several outhouse tops were blown off and trees were blown down, and east of here it blew down part of the Providence School building, some outhouses and trees."

Agricola, Susanna, and the Red Ridge settlement, Tallapoosa County.—Report of Dr. W. B. Fulton, rainfall observer at Dadeville: The storm occurred at Agricola, Susanna, and the Red Ridge settlement at 3:30 p. m.; it came from the southwest and went toward the northeast; the funnel-shaped cloud was observed; trees in all sections of the path pointed north; the path of greatest destruction was one-fourth mile wide; unable to estimate the amount of damage—one mule, two automobiles, in fact, everything in the path of the storm; 11 killed, 40 odd injured. According to the Montgomery Advertiser, property damage in the county will exceed $100,000, with from 50 to 60 large and small dwelling houses in the path of the great blast wrecked.

Extract from a letter to the editor of the Montgomery Advertiser on April 4, 1920, from Dr. Lyman Ward, cooperative observer, at Camp Hill: "* * * East of Camp Hill the damage was not so bad and there were no fatalities. Several tenant houses were blown down and many barns unroofed. * * * It is not known definitely the exact number of fatalities, but it will reach 14 or 15. Several children were badly injured and a number of adults are suffering from broken bones or wounds. Fifty families are homeless, food, clothing and rations all gone. * * * The loss will be over $200,000.

Alexander City, Tallapoosa County.—Press reports: Extract from the Birmingham Ledger for March 29, 1920: "The storm struck about 2 o'clock Sunday afternoon and did not let up until nearly 4. Five inches of rain fell at Alexander City in less than an hour. Little damage from the wind was felt here."

Waverly, extreme northwestern Lee County.—Postmaster W. O. Watson's report: "The storm was 4½ miles distant from this place. No damage to buildings or timber here."

Opelika, Lee County.—Postmaster R. D. Williamson's report: "The storm did not occur in this immediate vicinity, although there was a severe wind which blew down a number of trees and the roof off one house."

Between Waverly and West Point, Ga., no reports of damage were received.

It may be noted that the tornado must have crossed the Coosa, Tallapoosa and Chattahoochee Rivers in its path across nearly half of Alabama.

THE CEDAR SPRINGS OR WELLINGTON CREEK TORNADO.

Comparatively nothing can be learned of this tornado except what is contained in the following quotation from an article in the *Anniston Star* for March 29:

> Bennie Bowman, an 8-year old boy, was instantly killed Sunday afternoon near Cedar Springs, Calhoun County, when a cyclone dipped into a mile section of that part of the county; the residence and outbuildings of Jim McFall, at whose home the dead boy was visiting, was blown to pieces and scattered over a territory of half a mile * * * The cyclone of Sunday afternoon followed the course of a similar visitation along Wellington Creek about 10 years ago. The storm struck the ground a short distance southwest of Cedar Springs, blowing down timber, fences, telephone lines, houses, barns and outbuildings for a mile's space, and left the ground at a point near the West Point schoolhouse. * * * The barn of Mr Holmesley was carried a distance of several hundred yards, and the feed stuff it contained was practically ruined, a fine cow being reported killed and other stock injured in the same wind that carried destruction into several of the farms of that neighborhood.

The probable paths of the two tornadoes, together with the location of places mentioned in this report, are shown by the accompanying map (fig. 10).

NOTE.—The time used in this report is 90th meridian Standard, except the noon humidity values are for noon local mean time.

IN GEORGIA.

The following is an estimate of the loss of life and damage to property, taken from reports or newspaper accounts, viz:

West Point.—Ten people killed; property damage, $250,000.

La Grange.—Twenty-seven people killed; property damage, $1,000,000, including chiefly the plants of the Swift Fertilizer works and the United Mills Co. (cotton), and the settlements around them.

Macon.—One person killed; property damage, $500,000.

Washington.—No one killed; property damage, $100,000.

Milner.—No one killed; property damage, $10,000.

In every case the property damage corresponds to newspaper estimates, and in my opinion, are all ten times too large.

The storm which struck West Point at about 3:30 p. m., and La Grange half an hour later, was probably a tornado, but the disturbances reported at other widely separated places, Macon, Washington, and Milner were only severe squalls. Even at Atlanta, which experienced no storm, the day was remarkably dark. The newspapers contained the usual accounts of the damage wrought by the storm and the distressing features connected with it. Thirty-four people were killed, mostly in the cotton mill settlement at La Grange, and a considerable number were injured but nearly all only slightly. The pontoon bridge at West Point was swept away, but the Chattahoochie River did not quite reach the flood stage, and the assurance, given by this office, that the river would not exceed the flood stage of 20 feet was of some value.—*C. F. von Herrmann, Atlanta.*

Macon.—The forenoon was sultry, but with moderate breeze from south and southwest, shifting to southeast at 3:05 p. m. During the afternoon the sky looked ominous to the north and northwest and muttering thunder was first heard at 4:45 p. m. The storm was apparently moving slowly from the southwest to the northeast. At 6:35 p. m. a gentle rain began, that gradually increased in intensity about 6:47 p. m., the wind shifting to the northwest. At 6:50 it was blowing hard from the northwest, and then suddenly the storm burst in all its fury, accompanied by heavy hail from about 6:50 to 7 p. m. The wind increased in force, and a maximum velocity of 59 miles from the northwest was recorded with an extreme velocity of 78 miles. The storm was very severe for about 10 minutes with deafening crashes of thunder, mingled with the pelting of hailstones and the howling of the wind, the velocity exceeding anything previously experienced at this station in 21 years. The darkness was intense and nothing could be seen except during the flashes of lightning. The roof of the instrument shelter was carried away and hurled about 50 feet, almost demolishing one of the large ventilators on the roof. The instruments, strange to say, were uninjured and this is rather remarkable since the sunshine recorder was fastened to the shelter immediately below the roof. The temperature did not fall as much as might have been expected, and only reached 61° from 79°. The rain gradually moderated and the temperature rose rather rapidly, reaching about 72° at midnight. The pressure rose about 0.14 inch and then receded about 0.06 inch. Hardly a house in Macon escaped damage of some kind, and the loss is estimated at about $500,000. A colored woman is reported killed by lightning.

The hail partially melted as it fell, and by 8 p. m. none was seen on the ground or roof.—*R. M. Geddings, Macon.*

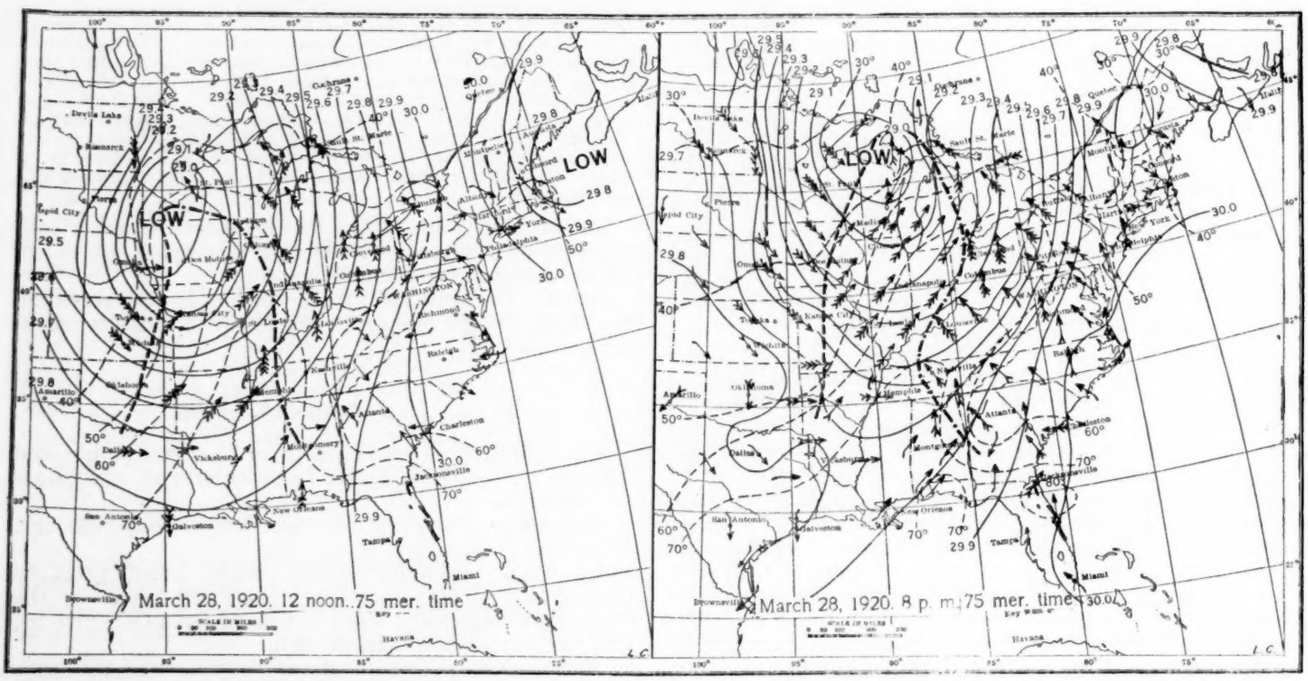
CONCLUSION.

Why did these 13 tornadoes occur on the afternoon of March 28? Let us review the facts as brought out by the weather observations:

1. There were strong, unusually warm winds from the southeast and south-southeast over a large area from the Gulf of Mexico to the Great Lakes.

2. A well-marked line (see dot-and-dash lines, figs. 8 and 9) separated these winds from still stronger, but slightly cooler, southwest or south-southwest winds in a belt immediately to the west.

3. Heavy thunderstorms, some with tornadoes and hail, occurred along this line of converging winds.



FIGS. 8–9.—Weather maps, March 28, 1920. (Barbs on wind arrows show wind force in Beaufort scale.) Wind-shift lines are shown by heavy dash and dot and dash line.

4. Immediately to the west of the northern portion of this line was a belt of diverging winds, characterized by brilliantly clear skies and exceedingly dry air, the driest on record at some stations. (Note surface wind-arrows on fig. 7.)

5. Kite observations indicated the presence of cold southwest-west wind at a moderate height overrunning the warm surface wind.

6. The northeastward movement of the tornadoes and lower clouds and the fall of hail on or to the east of tornado paths indicated a southwest to, at least, west-southwest wind not far aloft.

Surely this was an unusual set of conditions. With winds meeting at an angle of about 60° and at a rate of about 30 miles an hour, large volumes of air were sent upward and given a counterclockwise rotary motion by the thrusts of the southwest squalls routing under the rear portions of the slower north-northwestward-moving masses of warmer air. At a moderate height condensation took place in the moist, upthrust air, and as it ascended at a lesser rate of cooling, due to the liberation of latent heat of condensation, it probably was squeezed aloft at an increased rate by the cold wind it was probably encountering. Under such conditions intense vertical movement accompanied by a rotary motion of small dimensions makes a tornado.—*Charles F. Brooks.*

THE FOUR TORNADOES OF APRIL 20, 1920.

INTRODUCTORY NOTE.

The tornadoes of April 20, which were even more destructive than those of March 28, were apparently the result of a cold northerly wind overrunning the southerly surface wind. There was apparently no line of wind convergence, as in the case of March 28; but the striking feature is the formation, at approximately 60-mile intervals in a north-south line, of four tornadoes which swept along parallel paths from Mississippi into Alabama and Tennessee. The regular formation of these storms probably indicates the successive stages of the advancing cold air aloft; and the location of this front could be roughly determined by a line drawn through the synchronous positions of the tornadoes. According to newspaper accounts, which seem reliable, "loss of life * * * in Mississippi, Alabama, and Tennessee stood to-day [April 24] at 229 persons, with at least 700 injured, and a property loss of several million dollars."—EDITOR.

TORNADOES IN EASTERN MISSISSIPPI, APRIL 20, 1920.

By J. H. JAQUA, Observer.

[Meridian, Miss., May 21, 1920.]

Eastern Mississippi was visited on April 20, 1920, by the most destructive tornadoes of record in the area involved. A total of 130 persons were killed, 659 injured, and approximately 1,000 were rendered homeless. Incomplete statistics show that the property loss, exclusive of damage to crops, will approximate $1,500,000, which does not include damage done to standing timber.

METEOROLOGICAL CONDITIONS.

The morning weather map for April 20 shows the presence of an oval-shaped cyclone over the lower Mississippi Valley States (see fig. 1), the disturbance having made little eastward progress in 24 hours, but having materially changed its general shape. The pressure gradient over eastern Mississippi was about 0.1 inch to 75 miles. The barograph trace at Meridian shows that a slow fall in pressure had been in progress between midnight and 7 a. m. (See fig. 2 on plate facing p. 192.)

Temperatures ranged from 70° F. at Corinth to 75° F. at Meridian, or 10° F. in excess of the normal mean for the day. The northwest to southeast temperature gradient was probably not more than 5° F. in 120 miles. The trend of the isotherms was regular for the prevailing condition, and there was apparently a sharp wind-shift line, north and south through western Mississippi. (See fig. 1.)

The relative humidity was 86 per cent at 7 a. m., and had been practically stationary during the night, which was cloudy and sultry.

The conditions shown indicated the development of thunderstorms of convectional origin, and it was believed that the probability of the formation of tornadoes was not well decided. The most favorable feature that would warrant an assumption of the existence of incipient tornadic condition was the general atmospheric stress, which is frequently present under various arrangements of the isobars, but not as frequently productive of violent whirls. The rising humidity and abnormal surface temperatures prevailing in a season when the vertical temperature gradient is usually large indicated great

FIG. 1.—Weather map, April 20, 1920. (Barbs on wind arrows show wind force in Beaufort scale.) Wind-shift line heavy dashed.

convectional activity. That there existed probably a steep vertical gradient appears to have been demonstrated by the short funnel of the tornado at Meridian, as the cloud appeared to be a mass dragging over the surface. None of the tornadoes was spectacular in appearance, such as are frequently represented in photographs.

DISTRIBUTION AND POINTS OF ORIGIN.

Investigation made subsequent to the occurrence of the tornadoes discloses that four distinct storms were in progress between 7:30 a. m. and 11 a. m., their tracks being nearly parallel and practically the same width. Great damage was done in 14 counties out of 21 counties, which constitute a double tier extending northward from Jones and Wayne Counties to the Tennessee-Mississippi line. (See fig. 3.)

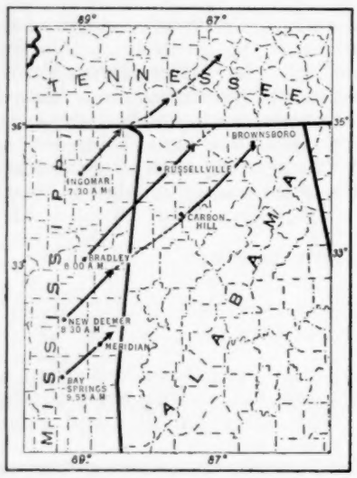


FIG. 3.—Tornadoes in Mississippi, Alabama and Tennessee, April 20, 1920.

Each tornado originated on, or slightly west, of the 89th meridian of west longitude and moved nearly due northeast at the rate of 50 to 60 miles per hour for a distance averaging 57 miles, except that the one originating in Oktibbeha County had a path of destruction which exceeded 80 miles and extended into the State of Alabama.

UNION COUNTY TORNADO.

The northernmost disturbance developed near Ingomar, in Union County, between 7 and 7:30 a. m., and moved northeastward across Tippah, Prentiss, and Alcorn Counties. The path of destruction ranged in width from one-eight to one-fourth mile. This tornado caused the death of 24 people and injured 167.

OKTIBBEHA COUNTY TORNADO.

The track of the next disturbance, which was over 80 miles long, lies about 66 miles south of the track of the northernmost tornado. It first became a destructive force about 8 a. m., near Bradley, in Oktibbeha County, from which point it crossed Clay and Monroe Counties into the State of Alabama. Reports state that in Clay and Oktibbeha Counties the devastated area is from 200 to 300 yards wide, but that in Monroe County it is one-fourth mile.

It was most destructive in Monroe County, where also the greatest number of fatalities occurred. There were 27 persons killed in that county, 150 injured, and about 500 left homeless. More than 110 dwellings were obliterated.

NESHOBA COUNTY TORNADO.

The third tornado originated about 8:30 a. m., in the southwestern portion of Neshoba County, and its path lies about 40 miles south of the Oktibbeha County storm.

It crossed Neshoba County and the southeastern corner of Winston County into Noxubee County, disappearing in Lowndes County. It was terribly destructive throughout its entire length, the width being one-fourth mile. The greatest loss of life occurred near New Deemer in Neshoba County, where 19 lives were lost in a lumber camp.

JASPER COUNTY TORNADO.

The southernmost and probably the most destructive of the series of four tornadoes developed near Bay Springs in Jasper County, about 9:55 a. m., and moved northeastward almost diagonally across Jasper and Lauderdale Counties.

The estimated damage to property in Jasper County is greater than in any other county traversed by the tornadoes of this day. Twenty-one persons were killed and 110 injured. The relief committee for that county reported that 156 families were affected by the storm, 20 of which had one or more members permanently injured, and 103 occupied buildings that were swept away or seriously damaged.

This tornado entered Lauderdale County at the southwest corner and began its work of destruction near Savoy; thence it continued northeastward to the Enterprise Road. The settlement at this point was the first important district to suffer devastation. It lay at the foot of a range of low hills, which the storm crossed, snapping off large trees like kindling wood and descending on the district with practically the suddenness of a flash of lightning. Not a house on this road for the distance of one-fourth mile was left standing. Most of them were so completely obliterated as to leave little evidence of their previous existence. From the Enterprise Road the storm crossed the broad plain below Hamiltons Lake, destroying most of the settlement at this point, where four people were killed. The tornado, when passing Hamiltons Lake, was about 6,150 feet southeast by south from the Weather Bureau Office at Meridian. Its least distance from the station was about 5,750 feet, at a point about 2,500 feet northeast of Hamiltons Lake. (See barograph trace, fig. 2 on plate facing p. 192.)

From the lowland the tornado passed up the foothills over the Mountain Road, crossing wooded hills and intervening vales, with no apparent loss of energy, to the Bonita district. In this section there was great destruction, but only one life was lost. About 25 houses were wrecked, including the Bonita public-school building and the Oak Grove Church building.

After moving about 1 mile beyond Bonita, the storm disappeared between Russell and Marion. The path of destruction averaged close to one-fourth mile in width, throughout the 5-mile course of the tornado off the city limits. The tornadic character of the damage was evident from the position of the fallen walls of houses and débris, wherever they were not carried away by the whirl, the walls being thrown outward.

In Lauderdale County, 15 people were killed, 81 injured, and over 100 families were left homeless. The total property loss, closely estimated by the relief committees, was $155,000. Owing to the unusual backward character of the spring season, the damage to crops was slight.

NOTES.

It is perhaps worth noting that the apparent north-to-south progress of the incipient tornadic condition from near Bradley to New Deemer, a distance of 50 miles, required nearly exactly the same time as for the Oktibbeha County storm to move from Bradley to Aberdeen, a distance of about 45 miles. In other words, when one tornado was passing Aberdeen, the next one to the southward was just becoming a destructive force.

The apparent southward progress of the condition was nearly twice the velocity of the forward movement of the tornadoes, except in the case of the southernmost storm, which developed rather slowly, as the first three had practically spent themselves before the last one was created.

At Mr. J. M. T. Hamilton's place, near Meridian, a drill-press weighing 150 pounds was carried about 150 feet; also a vise, weighing 100 pounds, was carried 150 feet away.

Near Bay Springs an automobile was blown several hundred yards; the spokes were torn from the wheels and tires from the rims. Three of the tires were found still inflated.

An automobile locked in a garage was undamaged, although the garage was blown to splinters.

Half a dozen glass jars of fruit were carried 100 yards by the winds and not damaged.

Legal documents from Bay Springs were found on the mountain, near Meridian, 50 miles from their point of origin.

Several photographs carried by the whirl from Jasper County have been found near Meridian.

The damage done to small towns and settlements lying within the path of the tornadoes was enormous. When the storms encountered heavily timbered sections, the paths of destruction suggest the swaths left by mowing machines. Large trees were snapped and wrung as if they had been limp rags, and the ruins present a spectacle of chaos that only fire could make more complete.

INTENSE DARKNESS.

At Meridian the cloud layers gradually thickened between 10:15 a. m. and 10:30 a. m., when it was very dark, with occasional flashes of vivid lightning. The darkness between 10:30 and 10:39 a. m. was as intense as would be common for a cloudy moonless night at 9:30 or later, and though lights were on in business houses (but no street lights were in operation), pedestrians could distinguish each other only with great difficulty. There were a great many excited people on the streets, and in many of the office buildings and department stores there was nearly a panic among the employees and others who were hurriedly leaving the buildings. The pall of darkness was so unnatural that it was extremely weird. People riding in automobiles state that steering was difficult even with lights on. At 10:31 a. m. the clouds in the southwestern horizon took on a greenish tinge, and at 10:36 a. m. the darkness was less intense for about three minutes. At 10:39 a. m., the darkness returned, the greenish tint being now of a yellowish green, pulsating in different degrees of intensity. The second period of darkness continued until about 10:55 a. m., and was, perhaps, more intense than the first period. The sky during the darkness was covered by a heavy curtain of clouds of stratus to nimbus structures, hanging nearly to the horizon, which was a narrow ring of light.

THE TORNADOES OF APRIL 20, 1920, IN ALABAMA.

By P. H. SMYTH, Meteorologist.

[Weather Bureau, Montgomery, Ala., June 3, 1920.]

METEOROLOGICAL CONDITIONS PRECEDING THE TORNADOES.

The disturbance in the Mississippi Valley (see Fig. 1) was attended in Alabama by southeasterly winds, generally less than 10 miles per hour, except along the coast, where they reached 22 miles per hour. A pronounced wind-shift line extended from southern Louisiana to Chicago, Ill. Morning temperatures were unseasonably high, the 7 a. m. isotherm of 70° F. extending as far inland as Nashville, Tenn., with temperatures as high as 76° F. recorded at Meridian, Miss., and Centerville, Ala., and a temperature of 74° F. at Montgomery, Ala., but somewhat lower temperatures prevailed on all sides of the area comprising these three stations.

Light rains had fallen within 24 hours at 18 stations in Alabama, mostly in northwestern and extreme western counties. Thunderstorms had occurred within 12 hours at Corinth and Vicksburg, Miss., and Birmingham, Ala. The sky over most of the State was overcast with clouds, exceptions being noted at Ozark, Milstead, and Selma, with partly cloudy weather, and Evergreen and Thomasville, with clear skies. At Montgomery the clouds were stratus, completely covering the sky and moving at 7 a. m. from the south; and these clouds continued throughout the day without breaking, shifting to the southwest late in the afternoon. Relative humidity at Montgomery at 7 a. m. was 80 per cent; at noon, 78 per cent.

METEOROLOGICAL CONDITIONS FOLLOWING 7 A. M. OF APRIL 20.

The storm that was centered between Memphis and Vicksburg at 7 a. m. of the 20th moved northeastward and was centered on the morning of the 21st over the lower Lake region, with increased intensity. It was attended in its passage by rainfall over nearly all except extreme southern Alabama, heavy rains (ranging from 1.25 inches at Riverton to 3.10 inches at Tuscaloosa) over much of northern Alabama, scattered thunderstorms in some central and northern counties, and the most destructive tornadoes of record for Alabama in the northwestern and north-central portions of the State. The sky remained overcast over nearly all the State during the 20th. Nevertheless, unseasonably high maximum temperatures were reported at most stations, ranging generally above 75° F. and reaching 85° F. or above at four stations, the highest being 87° F. at Auburn. Hail was reported from several points along the paths of the tornadoes, but from no other places in the State on the 20th.

THE TORNADOES—GENERAL SUMMARY.

Information at hand shows two tornadoes to have struck in Alabama, one crossing the Alabama-Mississippi line into Marion County, 5 miles northwest of Detroit, Lamar County, and the other reported first in northeastern Fayette County. Moving northeastward in nearly parallel tracks about 40 miles apart they cut swaths ranging from 100 yards to nearly a mile wide for a combined distance of about 180 miles through the whole or parts of 10 counties in Alabama. Estimates based on all available information place the number killed at not less than 89 persons, the number injured at about 500, and the property damage done at approximately $2,000,000 in Alabama alone. In some cases the injured were not expected to survive and in some counties, notably Winston, information could not be obtained from outlying districts and the death list may exceed the above estimate. For the amount of destruction these tornadoes exceed any of record in this State. The funnel-shaped cloud was observed by several reporters in the case of both tornadoes; both were observed to be counterclockwise in circulation, moved at an average rate of about 40 miles per hour, were attended at points along their paths by thunder and some hail, and were probably of about equal intensity. Heavy rains followed the tornadoes at several places in the vicinity of their tracks but in no cases preceded them, nor is there a record of heavy rain during the passage of either tornado. The feats and freaks of the storms were almost unbelievable. Houses were obliterated, forests in the centers of the paths of the tornadoes were literally swept clean, and objects in some instances were carried a distance of 75 miles. Slight earthquakes were felt just previous to the passage of one of the storms. Casings were stripped from the wheels of an automobile during the passage of this storm, showing the rapid and extreme decline in pressure. All along the paths of both storms observers noted the extreme density of the clouds; many state that it was the darkest midday in many years and one report is that chickens went to roost. Details of each storm are given in full below:

THE MARION COUNTY TORNADO.

This tornado, so called from the name of the county in which the greatest damage in Alabama was done, crossed the State line from Mississippi into extreme southwestern Marion County about 9 a. m. Moving exactly northeastward, it cut across the northwestern corner of Marion County, entering Franklin County near Hodges. Continuing in the same direction it crossed Franklin County, just touching Colbert County at the extreme southeastern corner near Mehama, from whence it whirled into northwestern Lawrence County, to be last heard from at about 11 a. m. in Alabama near the Tennessee River, northeast of Town Creek. It is not known whether the storm crossed the Tennessee River and Limestone County into Tennessee, but certainly no great damage was done farther to the northeast of northwestern Lawrence County in Alabama.

The destruction was terrific. Forty-four persons were killed or died from injuries sustained, about 315 were injured, some of them very seriously, and enormous damage was done to property. In Marion County alone 20 persons were killed and between 100 and 200 injured, while the property damage was conservatively estimated at $500,000. In Franklin County at least 19 were killed and perhaps 100 injured and property loss equal to or greater than that in Marion County was sustained. Four were killed and 15 or more injured in Colbert County, and 1 was killed and 8 or 10 injured in Lawrence County.

The width of the path of great destruction ranged from about 200 yards to eight-tenths of a mile and may have been wider in places, with one newspaper report placing the width at a mile and a half. The average width was probably close to one-half mile, making this storm considerably larger than usual.

It was this tornado that blew the casings off the wheels of an automobile and probably occasioned the earth tremors as mentioned in the general summary above, and it was this storm also that carried an insurance policy from Marion County to the vicinity of Killen, Lauderdale County, a distance through the air of about 75 miles. One observer near Hamilton reported that on the ground in front of the tornado cloud he saw what looked like a fire.

Detailed reports from various sections along the path of this tornado are given below:

Detroit, Lamar County.—Postmaster's report: Storm entered State about 5 miles northwest of Detroit; went in northeast direction through Marion County. No hail was observed, but thunder and heavy rain. Time of storm, 9 a. m.; it came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the storm's path lay to the south; in the center, twisted; on the south side of the path, to the north. The path of great destruction was fully one-half mile wide. His estimate of destruction for Marion County made on April 26, 1920, was as follows: Number killed, estimated at 20; injured, 100; property damage, not including crops, $150,000. * * *

Bexar, Marion County.—Postmaster's report: Storm occurred 2½ miles south of Bexar, about 9.30 a. m.; it came from the southwest and went toward the northwest. The funnel-shaped cloud was observed. Trees on the north side of the path lay toward the southeast; in the center, toward the east; on the south side of the path, toward the northwest; width of path of great destruction, one-half mile; property loss in vicinity of Bexar, not including crops, about $75,000. Number killed in vicinity of Bexar, 9; injured, 49. * * * No hail; about one-half inch rainfall; shocking thunder; peculiar clouds, consisting of upright layers of black and yellow, revolving from west around south, to east, to north, to west.

Hamilton, Marion County.—Postmaster Charles E. Mitchell's report: Storm occurred on route 4 and route 2 from Hamilton at 10 a. m. Beginning near the southwest corner of the county, it extended in a northeast direction, entering Franklin County. It came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the path pointed to the south; in center, both ways; on south side, to north. The path was about 0.8 mile wide. Damage for Marion County estimated as follows: Buildings, $100,000; household effects, $50,000; live stock, $50,000; farm implements, $50,000; all other property, $100,000; timber, $100,000; feedstuff, $50,000; total, $500,000. Number killed in Marion County, 20; injured, 200. No thunder; no hail. * * * Mr. Mitchell's report was dated April 26, 1920.

Extracts from *Marion County News*, Hamilton, Ala., April 21, 1920: * * *

"Everything went like leaves when the wind came," said Ben Crane, operator of a sawmill. "There first appeared something that looked like a fog, and the wind soon came roaring like a train. Not a building was left. We had 20,000 or 25,000 feet of lumber stacked; now it is scattered and blown away." Crane's mules were blown 100 feet from the barn, but were uninjured.

Volunteers are cutting new roads. * * * Twenty physicians from near-by towns are in Hamilton.

Guy Cantrell says: "I was in a room by myself. I started to go across the hall, where other members of our family were. As I entered the hall I saw the stairs blow out. I was carried into the yard. A feather bed blew by me. I thought it would keep the sticks from hurting me, so I wrapped up in it, trying to keep it under me. I came out with small bruises."

Banks Fowler: "I live on the west side of the creek. I saw the cloud and watched it come up the bottom. I could hear the cracking and snapping with the roaring. It looked like a fire on the ground in front of the wind."

Shingles were driven into sound oak trees.

J. P. Sanderson said: "There seemed to be two puffs of wind; one carried things toward the west. In about a quarter of a minute everything came back. I tried to keep my family down on the floor. One of my boys blew out of the house; then blew back. There was a part

of the floor of my house left—the part we were on. Even the sills were blown from under the room we were in."

A Ford car belonging to Edgar Byrd was blown a quarter of a mile over a field. * * * A conservative estimate by tax officials makes $500,000 the damage done to property. * * * Damage to timber will be at least $200,000, probably more. A strip 1½ miles wide by 25 miles long was swept clean. People who had seen many storm paths say this is the worst they have ever seen. * * * A house 2 miles west of Barnesville was demolished and a letter addressed to the owner was found four miles north of Russellville.

Extract from the *Sylacauga Advance*, Sylacauga, Ala., April 23, 1920: The shotgun wound sustained by Mr. Will M. Baker, the young farmer living near Hackleburg, Marion County, when a shotgun hanging on the wall was discharged as it fell from the force of the tornado * * * proved fatal.

Extract from the *Marion County News*, Hamilton, Ala., April 28, 1920: In Marion County it was found by the Red Cross survey that 100 homes were hurt by the storm—87 of them entirely demolished. From these homes 500 men, women, and children are now being cared for.

A friend sends us a blank used in this county by justices of the peace. He says it had drifted to J. N. Chafin's farm, 10 miles northeast of Russellville, on Fox Trap Creek. He also says Mr. Brooks found some clothing and pieces of timber in Hill's Beat, Franklin County.

Guin, Marion County.—Mr. Mack Pearce, cotton region observer's report: Storm occurred on the western side of Marion County about 9 a. m. It came from the northwest and went toward the northeast. The funnel-shaped cloud was observed. Trees in the center and on the south side of the storm's path lay in all directions. Thunder but no hail. Mr. Pearce's report is for Marion County, and is not dated. Reference to Form No. 1005-Met'l. from Guin shows for April 20: Maximum temperature, 76°; minimum, 71°; temperature at 7 a. m., 72°; precipitation for 24 hours ending 7 a. m., 0.15 inch; wind direction at 7 a. m., south; state of weather at 7 a. m., cloudy; prevailing wind direction for the day, south; character of the day, cloudy.

Hodges, Franklin County.—Postmaster's report: Storm occurred about 3 miles south of Hodges at the nearest point about 10 a. m.; it came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on either side of the path were pulled to the center and the ones in the center fell in different directions. Width of path at point of great destruction about one-fourth mile. Very little hail fell; there was thunder and a heavy rain. Clouds were yellow in places and very black.

Phil Campbell, Franklin County.—Postmaster's report: Storm occurred 8 miles west of Phil Campbell about 10.30 a. m.; it came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the northwest side of the path lay toward the south; in the center, toward the northwest; on the southeast side, toward the north. The path was from one-fourth to one-half mile wide at points of great destruction. At least $25,000 damage was done; this is very close and not at all exaggerated. Three were killed; 40, injured. Fighteen homes entirely blown away and several others damaged, and a great many barns and outhouses destroyed. This is only in the territory west of Phil Campbell between Big Bear and Little Bear Creeks, a strip one-fourth to one-half mile wide and about 5 miles long. No hail; thunder and heavy rain. Clouds were very dark; it resembled twilight.

Spruce Pine, Franklin County.—Postmaster W. H. Wade's report: Storm occurred 1 mile north of Spruce Pine between 9 and 10 a. m.; it came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north and south sides of the path pointed to the center; in the center they lay in every direction. Width of path at points of great destruction, about 200 yards. Damage, except to crops, about $6,000; this for about 6 miles of the path traveled through this section. One negro child was killed; seven persons were injured. I am only making a report of what we call the Spruce Pine territory, a strip about 6 miles long come southwest of Spruce Pine northeast of Spruce Pine. Everything in center of cyclone was swept clean. A little hail fell; there was thunder, heavy rain, and peculiar clouds.

Waco, Franklin County.—Mr. J. E. Franks's report: The storm occurred at Waco about 10 a. m.; it came from the southwest and went toward the southeast. The funnel-shaped cloud was observed. Trees along the path were crossed up in every direction. The path was about 200 yards wide. Lots of houses torn to pieces and stock killed. Twelve were killed; 25 injured. There was a little hail; the hailstones were about the size of medium sized marbles. Thunder; continued slow all day. Little rain all the morning; heavy rain in the afternoon. Dark as midnight.

Waco.—Mr. John Landers' report: Storm occurred at Waco at 10 a. m.; it came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the storm's path lay toward the southeast; in the center, nearly straight; on the south side, north. The path of great destruction was a quarter of a mile wide. About $20,000 damage was done. Ten were killed; about 40 injured. * * * There was hail in the tornado; hailstones about the size of an egg. Very heavy thunder. In about half an hour after storm both rain and hail fell.

Extract from the *Florence Times*, Florence, Ala., April 30, 1920: Waco, the Government quarry in Franklin County, * * * was completely demolished by the cyclone Tuesday. Parts of the houses, half of the garage, and other parts of the débris were picked up in the streets of Russellville, 8 miles northwest of Waco, and parts of windows, doors, and even chairs and an old washstand were found in the hamlet of Littleville, 11 miles north of Waco, after the storm had passed. Stock was also picked up miles away. * * * A meager report stated that six were killed and the settlement of Waco destroyed. Later reports increased the number, verifying six killed in one family alone a mile from the quarry. According to reports the home section was all but wiped out. A carload of stone was whipped about like a feather, and trees, one especially large oak, were twisted from the roots as if they had been bits of wire. The half of an immense bowlder was found in Littleville, Colbert County, and several doors and window frames were seen in the little hamlet. One mule was picked up later in the day in the village with parts of the plow still dragging behind him. The animal was badly cut and bruised. Dr. Meriwether, of the United States Public Health Service, states that only two buildings are left in Waco—the superintendent's building and the office building—and both these are badly damaged; also that 12 quarrymen were hurt, * * * that others a few miles from the quarry were killed and still others injured. The hamlet of Waco is no more; that is, so far as the house section is concerned. It was right in the path of the storm which came up the valley, razing everything in its wake. * * * The cyclone is said to have been the worst that has ever visited this section. It apparently traveled at right angles to the Southern tracks, and dipped in two places, being deviated in its path by a small tract of completely inundated land. Just between the two points or dips the portion of the country was practically unharmed—this was near Town Creek—and several cows in a near-by pasture were unharmed. * * * At Russellville and Littleville, on the side of the mountain, a slight shock or tremor of the earth was felt just previous to the storm, and a few minutes later a similar shock was felt in portions of the Wilson Dam Reservation and at United States Nitrate Plant No. 2. About the same time the lights went out, and the atmosphere seemed to be surcharged with electricity. One man, a stranger, was killed at Waco.

Newburg, Franklin County.—Postmaster F. S. Roe's report: The storm occurred 3½ miles west of Newburg about 9.30 a. m. It came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the path pointed toward the southeast; in the center, toward the northeast; on the south side, to the northwest. Width of path of great destruction, from 200 to 400 yards. There were 12 dwellings, barns, and outbuildings completely destroyed in 6 miles of Newburg. Ten were killed—nine in one family, a mother and eight children. Number of injured unknown. * * * Several more were killed north of here. There was hail, thunder, heavy rain after the storm, and very peculiar dark yellow clouds. Everything in the path of the storm was completely swept away; can not estimate damage; oldest people here never have seen anything like it.

From the *Tuscaloosa, Ala., News*, April 29, 1920: Reports from Gov. Kilby's office place the number killed in Franklin County at 19; number injured, 92. Fifty-seven homes in Franklin County were destroyed and 44 badly damaged.

The *Colbert County Reporter*, April 29, 1920, corroborates this statement.

Mehama, Colbert County.—Extract from the *Sheffield Standard*, Sheffield, Ala., April 23, 1920: In this county, Mehama, a small settlement south of Leighton, was practically wiped out. Here there were three deaths and many casualties. Trul Blanton, his wife, and one child were killed, and a score or more injured. Houses were destroyed and much live stock killed. * * * A freak of the cyclone was the destruction of a Ford automobile. The car was blown some distance and the casings stripped from the wheels. Near Town Creek one death was reported. Two were badly injured. The path of the storm extended from southwest to northeast.

From the *Tuscaloosa News*, Tuscaloosa, Ala., April 23, 1920: Report from Gov. Kilby's office * * * states number killed in Colbert County as 5; number injured, 15 or more.

From the *Sheffield Standard*, April 23, 1920: High winds in this city. Sheffield escaped any serious injury from the tornado. However, the residents were given a scare, as the clouds, winds, and heavy rains were such as to cause alarm. Lights were necessary in downtown offices and stores; for more than half an hour the electrical storm raged. The downpour of rain was almost equal to a cloudburst. Tuesday evening about 6 p. m. the strongest blow came, accompanied by terrific rain. * * * The strong wind caught the automobile of

Rev. Wm. R. Riggle, a five-passenger touring car, and blew it off the high bluff.

Town Creek, Lawrence County.—Report of Rev. S. V. Blythe: Storm occurred 1 mile southeast of Town Creek at 11 a. m. It came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the storm's path pointed south; in the center, north; on the south side, north and east. Trees and houses were blown down and scattered. Almost every house in its path blown to pieces. Some stock killed; 1 person killed; 8 or 10 injured. No hail; very loud and constant thunder; 2 or 3 inches of rainfall. Much corn and hay destroyed and meat. Report dated April 25, 1920.

Extract from the *Florence Times*, Florence, Ala., April 23, 1920: On Tuesday 1.72 inches of rain fell from 11:45 a. m. to 1:15 p. m., with the wind in at times variable directions and of great velocity. Also 0.74 inch fell in 45 minutes from 6 p. m. to 6:45 p. m. Electrical effects also reported. The wind in the evening was from the east almost constantly, and was of such velocity as to do great damage to young fruit trees. No serious damage was reported in any part of Lauderdale County. The heavy flow of water washed out part of the road from Florence to the nitrate plant, and a section of the newly built gunwale fore road a short distance beyond Locust Street was washed out to a depth of probably 10 feet. Greatest damage was done 30 to 50 miles south and west of here.

BLOWS POLICY 75 MILES.

As illustrating the powerful force of the tornado that passed over Alabama last week, it may be related that an insurance policy from a home in Marion County was blown into Lauderdale, it having been seen and recovered as it fell by Mr. Sam Ezell on Route 1 from Killen. The policy was on the life of Joel Clarence Ford in favor of his mother. The distance traveled in the air was about 75 miles.

From the *Moulton Advertiser*, Moulton, Ala., April 28, 1920: One of the most destructive cyclones which ever struck this county passed over the northwestern corner of Lawrence County last Tuesday morning, striking the county first at Mehama, and traveling in a northeasterly direction. At Mehama four were killed and seven houses were completely demolished and several persons more or less hurt. * * * Property damage, very conservatively estimated, was $24,000. * * * After leaving Mehama the storm swooped down on Wolf Springs and blew away the house of Mr. Harvey Carpenter and of a Mr. Garrison. A Mrs. Chaney had an arm broken. * * * The storm continued on its way doing minor damage until it struck Town Creek, * * * where it killed Mrs. John M. Roberts, of Wren. East of Russellville, and along a distance of 10 miles, it is known that 16 are dead and about 40 injuried.

Florence, Lauderdale County.—Extract of record of Special Meteorological Observer Miss O'Ella O. Coburn, Form No. 1001–A–Met'l for April: Sea-level pressure at 7 a. m., 29.67 inches; temperature at 7 a. m., 72°; maximum temperature, 76°; minimum temperature, 64°; rain began, D. N.; ended D. N.; rain began 11:45 a. m.; ended, 1:40 p. m.; rain began 6:30 p. m.; ended, 7:15 p. m.; total rainfall to 7 a. m., 0.04 inch; total for showers after 7 a. m., 2.46 inches; marginal note, severe storm. (All data for the 20th.) Wind direction 7 a. m., south; state of weather, cloudy; character of day, cloudy.

Riverton, Colbert County.—Extract from Form No. 1009–Met'l, April 20: Maximum temperature, 81°; minimum, 67°; temperature at 7 a. m., 73°; rain began D. N.; ended, D. N.; rain began 11.04 a. m.; ended 3.50 p. m.; total rainfall to 7 a. m., 0.07 inch; after 7 a. m., 1.25 inches; thunder and lightning; wind direction 7 p. m., south; state of weather, cloudy.

Tuscumbia, Colbert County.—Extract from Form No. 1005–Met'l, April 20: Maximum temperature, 77°; minimum, 67°; precipitation began and ended D. N.; precipitation began, 9.30 a. m.; ended, D. N.; amount of precipitation to 7 a. m., 0.05 inch; for remainder of day, 2.28 inches, wind direction at 7 a. m., southeast; prevailing for day, southwest; character of weather at 7 a. m., cloudy; for the day, cloudy.

THE MADISON COUNTY TORNADO.

This tornado, so called for the county in Alabama from which reports are most complete and where the destruction was notably great, apparently originated in northeastern Fayette County, Ala., as it was here that the first destruction was reported, but it seems highly probable from a backward projection of the line of the storm's path and in the light of available reports from Tuscaloosa and Pickens Counties that the place of origin was in Mississippi, and that this was the same tornado that was reported from Noxubee County, Miss. If so, it traveled above the ground at such a height and in such a manner that it escaped notice in western Alabama. From northeastern Fayette County the storm traveled northeastward through northwestern Walker County, passing near Pocahontas and Saragossa to the north of Manchester, striking Winston County near Falls City. It continued across southeastern Winston County, devastating Arley and Helicon, passing into northwestern Cullman County, northeast of Helicon, and into Morgan County near Wilhite. It seems to have done very little damage in Morgan County, and probably passed over this county at a considerable height in the air. It is next positively heard from crossing the Tennessee River into Madison County near Green Cove. Cutting diagonally across Madison County, it did terrific damage at Lily Flagg, sections southeast of Huntsville, and between Brownsboro and Gurley, and was lost sight of northeast of Brownsboro about 15 miles south of the Tennessee line. The destruction in Alabama by this tornado was about equal to that by the Marion County tornado referred to above. About 46 persons were killed and approximately 215 injured. Twenty were killed in Winston County, 1 in Cullman, and 25 in Madison. Property damage was probably nearly $1,000,000; an accurate estimate can not be made from reports at hand. In Madison County the storm did not cling closely to the ground, but struck here and there along its path. Some hail and thunder were reported from points in Madison County, notably south of Huntsville and near Brownsboro, and rainfall was generally light. The funnel-shaped cloud was observed to revolve counterclockwise, and is described as very heavy, black, and rolling like soft-coal smoke. Near Wilhite the cloud was black, with a yellowish tinge. Many farm animals were moved without injury from one farm to another, feathers were blown off chickens, and a pump was pulled out of a well and broken in two parts, the upper part disappearing completely. Details from various places along the path of the storm are given below:

Extract from the *Tuscaloosa News*, Tuscaloosa, Ala., April 20, 1920: Livingston, Ala., was visited by a severe hailstorm, but no damage done.

From the *Tuscaloosa News*, April 21, 1920: Bad storm did not reach this section, but rain did damage. There in Tuscaloosa, when that black cloud was hanging over the city, many people became frightened, and supposed they were going to get a taste of the tornado, but fortunately it passed away without striking us. The black cloud as it appeared in the west looked exceedingly angry. The force of the wind would shoot great waves of cloud above other clouds, and made it look as if we would not escape the fury of the storm. There was darkness in Tuscaloosa for the period of about an hour. Automobiles turned on their headlights when driving through the pelting rain. S. A. O'Quinn picked up a sea bird that had been driven to this city before the fury of the storm. The bird had a long beak and exceedingly long legs, and was found dead in the streets. It became so dark about noon that chickens went to roost. * * * It was the scariest looking cloud that has hung over this city in many a day, some saying that they had never seen it so dark at high noon.

Tuscaloosa, Ala.—Extract from Form No. 1009–Met'l, April 20: Maximum temperature, 75°; minimum, 72°; temperature at 8 a. m., 75°; rain began D. N.; ended D. N., both on the 19th; rain began 11 a. m.; ended, D. N., both on the 20th; rainfall to 8 a. m., 0.02; after 8 a.m., 3.10; prevailing direction of the wind, south; character of the day, cloudy.

From the *Greene County Democrat*, Eutaw, Ala., April 23, 1920: Tuesday at noon the clouds became so low, heavy, and black that one could scarcely read a newspaper in the open air, and one automobile drove through the streets with lights. The blackest noon we ever saw, followed by a downpour of rain. * * * Tuesday was a stormy day, with winds, floods, lightning, thunder, and rain.

From the *Greensboro Watchman*, Greensboro, Ala., April 22, 1920: Tuesday, the 20th, was the darkest and most threatening day that had been witnessed here in years. The air was heavy and cyclonic, and it was a feeling of great relief to everybody when the rain came without any wind. The storm went to the west and is reported to have done

much damage in portions of Mississippi. The rainfall here was very heavy—2.18 inches. (This paper is edited by Mr. Wm. E. W. Yerby, cotton region weather observer at Greensboro.)

Greensboro.—Extract from Form No. 1005-Met'l, April 20, 1920: Maximum temperature, 76°; minimum, 71°; total precipitation to 7 a. m., 0.18 inch; to 7 a. m. of the 21st, 2.18 inches; wind direction, prevailing, south; state of weather at 7 a. m., cloudy; character of the day, cloudy.

Cochrane, Pickens County.—Extract from Form No. 1006-Met'l, April 20, 1920: Rain began 10 a. m.; ended 6 p. m.; amount, 0.75 inch; wind direction at 7 a. m., south; state of weather, cloudy.

Jasper, Ala.—Extract from the *Mountain Eagle*, April 28, 1920: Winston County among sufferers. Reports are continuing to come in. In the Bennet settlement north of Manchester, the homes of Fred Wilson, Denny Messer, and John Wilson were completely destroyed, and the barns of H. J. Bennet and Wash Lamon were blown away. Some cattle were killed, but fortunately no lives were lost. The Union Hill Church was destroyed. Fences, wires, and trees were blown down. In Winston County, near Arley, the 6-year old son of Garrett Barens was killed in the storm of last Tuesday, and many houses and barns were blown completely away, and people left without food or shelter. * * * The small town of Helicon in Winston County was completely demolished; * * * not a building was left standing, and neighboring orchards and farms were ruined. * * * No loss of life is reported, and few were injured.

Cullman, Ala.—Extract from the *Cullman Democrat*, April 22, 1920: The worst storm in many years visits the county on Tuesday. On Monday dark clouds hung over this section of the county all day, and on Tuesday the same continued, with very little rain. On Tuesday about noon a distinct roar was heard for quite a long time. Many residents interpreted this roar as a cyclone passing at no great distance from Cullman, and it developed they were correct. The storm, which did no great damage in this city, seems to have passed a little to the northwest of Cullman, near Vinemont, going on to Lacon, where two houses were destroyed within sight of the passenger train which stopped there. At Helicon, several miles northwest of Cullman, near the Winston County line, six are reported dead, and much damage done to property. * * * One or two deaths are reported from Wilhite. * * * Telephone linemen going north of here say they learned that a two-story house was blown away, 9 miles up the Old Corn Road, and a Mrs. Lewis, 70 years old, killed by a falling chimney. Around Hanceville many outbuildings had tops blown off, and several chimneys were blown down. The large barn of S. J. Griffin was blown flat. This barn was only a short distance from Los Manning's home, which was not hurt.

Carbon Hill, Ala.—Extract from the *Carbon Hill Journal*, April 22, 1920: Although it was very dark and threatening at Carbon Hill, it was hardly considered that conditions were right for a tornado. * * * The rainfall at Carbon Hill was light and of short duration, although it was cloudy the balance of the day.

Cullman, Ala.—Extract from the *Cullman County Tribune*, April 22, 1920: In our county considerable damage was done by the cyclone. The twisting winds appear to have struck Cullman County in the western part. The little town of Helicon, just over in Winston County, was almost wiped out, there being only one home left standing. While no one was killed, many were injured, some of them seriously. The storm next struck in this (Cullman) county in the community of Nesmith, where much damage was done, the tornado cutting a path more than a quarter of a mile wide, sweeping everything clean. * * * Two houses were wrecked and many barns were unroofed. The next place visited was near Ebenezer Church, where three barns were unroofed. The next place to suffer was the home of J. W. Collum; his residence was completely demolished, and Mrs. Mary Collum, 83 years old, was crushed to death by a falling chimney. Mr. Collum and his two children were badly injured. T. W. Shannon's barn was blown down and a good mule killed. The storm next struck near Wilhite, where it blew down much timber, demolishing the large barn of G. W. Drake and tearing the porch off the Huffstutler home. Three barns were unroofed and the home of Sim King blown away. It next struck at Cold Springs, where it did considerable damage to smokehouses, barns, and small houses. * * * A dispatch from Jasper dated the 21st says that a cyclone passed over parts of Walker and Winston Counties about noon of the 20th and did considerable damage to property and killed one child near Arley. The storm started in the northern part of Fayette County, and passed through Walker County, touching Pocahontas, just this side of Carbon Hill, and blew down a stretch of timber three or four hundred yards wide. It struck the home of Mark Myers near Saragossa, and blew it down, injuring two of his children. It passed on by Falls City, leveling almost every house in its path. At Nathan, near Arley, it killed one person and injured another. Many farmers in the storm lost heavily in the destruction of feed, barns and stock.

From the *Mountain Eagle*, Jasper, Ala., April 21, 1920: The storm hit 9 miles northwest of Jasper, and the barn of Myers was blown down and the house off the pillars, but no one was injured. There were 11 head of horses and three cows in the barn and none of them was injured; how it happened was a miracle. The Union Hill Church, 12 miles north of Jasper, was also blown away, and the property damage in this section was very heavy, but no lives were lost.

St. Bernard, Cullman County.—Extract from Form No. 1009-Met'l., April 20, 1920: Maximum temperature, 73° F.; minimum, 64° F.; temperature at 4.15 p. m., 66° F.; rain began a. m ; ended, 3 p. m.; amount, 0.80 inch; prevailing wind direction, southwest; character of the day, cloudy.

Wilhite, Cullman County.—Report of Mr. G. W. Drake: The storm occurred at Wilhite station at noon. It came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side, south side, and in the center of the storm's path pointed to the north. The path was one-fourth mile wide. Property damage, about $5,000. One killed; three injured. There was hail and thunder; rain after the storm. Clouds were black, yellowish. The storm came to the ground at Wilhite and swept everything clean for about 2 miles, and then rose again and went 6 miles, coming down again at John Gurley's, where it did some harm.

Vinemont, Cullman County.—Postmaster's report: The storm did not affect my neighborhood; it was in the territory served by the Lacon post office.

Falkville, Morgan County.—Postmaster's report: Storm did not affect this place; it was 4 miles south of here.

Decatur, Morgan County.—Extract from Form No. 1005-Met'l., April 20, 1920: Maximum temperature, 75°; minimum temperature, 70°; temperature at 7 a. m., 70°; rain began D. N. of the 19th; ended 3.30 p. m. of the 20th; amount to 7 a. m., 0.03 inch; amount after 7 a. m., 0.16 inch; wind direction at 7 a. m., south; prevailing for day, south; state of weather at 7 a. m., cloudy; character of day, cloudy.

Lily Flagg, Madison County.—Report of Mr. J. M. Latham, dated May 1, 1920: The storm occurred 1½ miles south of Lily Flagg at 12.30 p. m.; it came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the path pointed to the south; in the center, to the northeast; on the south side, to the north. The average width of the path of great destruction was 150 yards. Damage, except to crops, $50,000. Eight were killed; nine injured. * * * No hail; no thunder; heavy rain; very dark, peculiar clouds. We saw the cloud—tornado—coming about 10 miles away. It was a dark, funnel-shaped cloud, whirling toward the northeast, going at a very rapid speed. There was very little noise until it got in a mile of us. It turned in the contrary direction to the movement of the watch. We stood on our porch and watched it about 15 minutes, watching things being whirled away.—*J. M. Latham, per Lillie Latham.*

Huntsville, Ala.—Report of postmaster R. L. Okal: The storm occurred 6 miles south of Huntsville at 12.30 p. m.; it came from the southeast and went toward the northeast. The funnel-shaped cloud was observed. Trees on the east side of the storm's path lay toward the west—branches were broken; in the center of the path, scattered and broken; on the west side, toward the east. Width of path of great destruction, about 200 yards. Damage except to crops, estimated at $35,000. Several substantial country homes were totally obliterated; not a piece of timber left to show where they stood. Twenty-one were killed; injured estimated at 35. There was hail, but very little; hailstones were about the size of filberts. Very little, but heavy thunder; rainfall was light. Clouds were heavy, black, and rolling, like soft coal smoke. I met a Mr. L. W. Baily this morning, who gave a clear description of the cyclone as he saw it from his front porch, as it passed up the cove about three-fourths mile from his home. He said the great, black, whirling cloud first appeared to him coming up from the southeast, small at the bottom and spreading at the top; that as it approached nearer all other clouds in the sky appeared to dash toward it and were swallowed up. It swept rapidly across the cove, moving a little north by northeast as it neared the mountain range, and went over it, leaving a path clear of any standing timber, houses, or fences. In going over the path of the storm the next day he and his sons found cedar trees, with trunks 16 inches through, lying on the upper benches of the mountain, that had been torn up by the roots down in the valley and brought up bodily and deposited among the big timber on top of the range. He also said that he saw quite a number of postholes where the posts had been pulled up and carried off; that the holes were large at the top, as if the posts had been twisted around before coming out of the ground. Numbers of other posts were broken off even with the surface, but not a post was standing in the path. The storm came into Madison County from Morgan County. One citizen of Madison saw the great, black, rolling cloud pass across the river at a distance of several miles, moving east, he said. He saw it spread toward the earth after crossing the river, but did not know of the damage done, until the next day. It struck the earth in Madison about 4 miles east of the Whitesburg Pike, beginning its work of destruction at this point. It was what you might call "a bounder" as it did not cling closely to the ground all the way up through Madison County. If it

had, the loss of life and destruction of property would have been greater still.

Huntsville, Ala.—Extract from the *Huntsville Telegram*: * * * Mrs. Newt Flippin suffered the amputation of an arm, which was twisted off by the wind. The wind performed many freak stunts with cattle, moving many animals from one farm to another without injuring them, and blowing the feathers off chickens. Many farm animals were killed, however. The pump at Flippin's home was pulled out of the well and broken into two parts, the upper part not having been seen since the storm. The property damage is estimated at about $50,000 to houses and barns, and there was very little damage to crops because of the lateness of the season. * * * Practically no one had tornado insurance.

Owens Cross Roads, Madison County.—Postmaster's report: The storm occurred at Brownsboro, route No. 1, at 12:30 p. m. It came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the path pointed toward the south; in the center, in all directions; on the south side, to the north; width of path of great destruction, 300 yards. Damage, except to crops, $2,500. Four killed, 10 injured. * * * No hail; thunder, but no heavy rain; black cloud.

Gurley, Madison County.—Postmaster M. I. Williamson's report: The storm occurred west and north of Gurley at 12:30 p. m. It came from the southwest and went toward the northeast. The funnel-shaped cloud was observed. Trees on the north side of the path pointed to the north; none left in the center; on the south side they pointed to the south. Path of great destruction was 60 yards wide. Damage, except to crops, $25,000. Nine were killed; 10 injured. * * * The storm did not cut a clean path. It dipped here and there along the path, and went clear over trees in other places. Where it did strike the earth, it swept everything clean.

Brownsboro, Madison County.—Postmaster's report: The storm occurred 1 mile east of Brownsboro at 1:15 p. m.; it came from the west and went toward the east. The funnel-shaped cloud was seen. Trees on the north side of the path pointed southward; in the center, eastward; on the south side, northward. Path of great destruction was 100 yards wide. Fifteen houses, 12 barns, and about a thousand dollars' worth of timber totally destroyed. Thirteen killed, 18 injured. A little hail; hailstones small. Thunder very heavy; little rain fell.

Madison, Madison County.—Extract from Form No. 1009 Meteorological, April 20: Maximum temperature, 73°; minimum, 67°; temperature at 6 p. m., 68°; rain began at noon; ended, 1 p. m.; amount, 0.38 inch; prevailing wind direction for the day, south; character of the day, cloudy.

Scottsboro, Jackson County.—Extract from Form No. 1009 Meteorological, April 20: Maximum temperature, 76°; minimum, 66°; temperature at 5 p. m., 66°; rain ended 1 p. m.; amount, 0.40 inch; prevailing wind direction for the day, southwest; character of day, cloudy.

The following newspaper extracts may be of interest as showing the weather at points off the storms' tracks:

Greenville, Butler County.—From the *Greenville Advocate* for April 23: Speaking of the 20th, all day the wind was blowing a gale, and many people feared the storm would reach here.

Sylacauga, Talladega County.—From the *Sylacauga Advance*, for April 21: Referring to the 20th, heavy thunder and electrical storm; * * * a smokehouse was damaged by falling trees.

90th meridian time used throughout this report.

Figure 3 shows the location of the storms' paths.

IN TENNESSEE.

A tornado occurred on April 20, 1920. On first consideration of the reports received we got the idea that two different tornadoes occurred, but further examination of the reports leads us to believe that it was one tornado striking the ground at intervals.

It first appeared in Wayne County about 9 a. m., passing about 3 miles south of Waynesboro at 9:15 a. m. Its course was from southwest to northeast. We have no reports of tornadic wind effects in Lawrence and Lewis Counties (northeast of Waynesboro), though very heavy rain occurred at Hohenwald, Lewis County, and heavy at Ashwood, Maury County. But there was no tornado in the vicinity of Hohenwald or Ashwood. However, at 10:30 a. m. a tornado struck in the vicinity of Spring Hill, Maury County, and near Burrwood and Thompsons Station, Williamson County, moving northeastward, in line with the track through Wayne County, made about 1 hour and 15 minutes earlier. It was probably the same tornado.

The map (fig. 3) shows approximately the path of the tornado. Its path was between Burrwood and Spring Hill, about 1 mile east of Burrwood and 3 miles west of Spring Hill. It was traveling directly toward Franklin, about 9 miles northeast of Burrwood, but did not reach Franklin. Apparently, its destructive violence ceased at a point 2 or 3 miles northeast of Burrwood and about 2 miles north of Thompson's Station.

In Wayne County property damage of about $5,000 was reported, but no lives were lost. In Maury and Williamson Counties the losses were heavier, being estimated at a total of $20,000. One man was killed and 8 or 10 persons injured near Burrwood, Williamson County.

The rainfall was very heavy in Davidson County, washing away some bridges and causing damages of $10,000 or more, while in Nashville the streets that were macadamized suffered to the extent, according to estimate, of $50,000.—*Roscoe Nunn, Nashville.*

TORNADO IN UNION COUNTY, N. C., APRIL 12, 1920.

By G. S. LINDGREN, Meteorologist.

[Charlotte, N. C., May 20, 1920.]

The low-pressure area, which gave rise to the tornado of April 12, 1920, in North Carolina, moved from the middle Mississippi Valley to northwestern Pennsylvania between 8 a. m. and 8 p. m. of that date. The general form of the LOW on the 8 p. m. map was that of a very much elongated ellipse whose major axis extended from the upper St. Lawrence Valley to the east Gulf coast. Thunderstorms with brilliant lightning occurred at Charlotte during the evening hours. There was little wind and about 0.86 inch rainfall. The barometer at that place dropped during the day, reaching a minimum about midnight.

The temperature gradient on the evening map was decidedly steep in the northwest quadrant, the current temperature at Pittsburgh being 60° F., and that at Toledo, 28° F., approximately 200 miles to the northwest.

At about 9 p. m. of the above date a tornado of marked severity formed in the northwestern part of Union County, 18 miles southeast of Charlotte, which caused the loss of three lives, seriously injured several persons, and inflicted considerable damage to cattle, farmhouses, timber, and orchards, the total loss being estimated at about $250,000.

Available records indicate that an average of about one tornado per year has occurred in North Carolina, but nearly all of these appear to have been of a light to moderate type. The loss of life or extent of destruction to property attending the passage of previous storms of this character is unknown, but the one under consideration will rank among the severest that have ever visited this section of the country.

The tornado path was about 32 miles long, running northeastward across Union County, extreme northwestern Anson County, and southeastern Stanley County, the last damage reported being 2 miles from the county line. Its width averaged about 150 yards, never being

more than 200 yards; the time occupied in passing was about 45 minutes.

The storm was attended by vivid lightning, moderate to light rains, and a little hail in Union County. A funnel-shaped cloud was seen in Stanley County, but none was observed in Union County, probably because of darkness. That it existed is evidenced by the position of the débris in the path of the storm and by the twisting of the trees that were uprooted or broken off.

The tornado first struck the home of Robert L. Polk, a farmer living about a mile from Ebenezer, killing him, injuring several members of his family, and demolishing all the buildings on the farm. At Ebenezer, the church and schoolhouse were swept away, but no other buildings were touched. Two miles beyond this place the storm seems to have been at its greatest intensity. All that is left of a large and substantial farmhouse is a pile of rocks; the barn is gone, and other outbuildings completely wrecked. A mule was hurled 100 feet against a tree stump, its body pierced by a 2 by 4 scantling; a horse was carried several hundred feet into a patch of wood, where it was found the following morning apparently unhurt; a steel range from the Preston home was found 3 miles away in a wheatfield; harrows, plows, and other agricultural implements were scattered over the fields for a mile around; a sewing machine was found hanging from a tree limb. Heavy live stock losses were sustained and an extensive orchard completely demolished. The path is marked by the wide swath of twisted and wrenched tree trunks where it passed through forests; but in several cases many houses directly in the storm track were spared. The tornado apparently came to an end in Stanley County, 2 miles west of the Yadkin River.

TORNADOES IN NORTHEASTERN OKLAHOMA, MAY 2, 1920.

There appear to have been three, if not four, distinct tornadoes that swept their trails of death and desolation across Rogers, Mayes, and Cherokee Counties. One struck just outside Chelsea and moved northeast, advancing about 5 miles before it rose. Its path was about a city block. This was at 6 o'clock. It resulted in five deaths. Another swept a path a half mile wide and 3 miles long across the Missouri, Kansas & Texas Railway right of way, 4 miles north of Choteau. Houses were tumbled in its path, but no one was killed. Scores of dead cattle and hogs were found in its wake.

The third storm wiped out Peggs, an inland town of 200 people, occupying a knoll among the foothills of the Spavinaw Mountains. At 8:35 p. m. the tornado leaped a protecting range of hills to the west, dipped into the valley, tore a path of devastation a mile wide and 3 miles long through the countryside, and disappeared. A heavy rain and hail accompanied it. On the following day the official count of the dead stood at 50 and the badly injured at more than 80. Three days later the death list was increased to 60. Most of the persons that remained unhurt after the storm had passed were those who had sought the protection of storm cellars.

The *Muskogee Daily Phoenix* of May 4 gives an account of the Peggs storm in great detail. A few excerpts follow:

> [Mr. A. J. Cagle's] family of seven were in the house when the wind crushed it. Two of his sons were blown through the wall into the roadway. Except for a few slight bruises they were unhurt. [Although the house was demolished, not one of the others was scratched.]
>
> A large hole was torn in the Robinson house [next door], and the roof of the back porch dropped to the floor. On the porch a refrigerator, heavily laden, stood between two washtubs. The wind picked up the refrigerator, sucked it out from beneath the roof, hurled it over the housetop, and carried it away. The tubs were not moved.
>
> Only one structure in the entire town escaped wholly unscathed. That building, a small one-story house of wood, is the "city jail." [It was unoccupied.] Not 30 feet from it the concrete store of Mr. Robinson lies in utter ruins.
>
> By the side of the road a mile from Peggs an automobile, tangled and twisted, had been driven halfway into the ground by the wind.

At the aerological station, Broken Arrow, Okla., 40 miles west of Peggs, an observation at 3 p. m. showed a general drift of the air from the southwest, the wind veering from south-southwest, 5 m/s at the surface and 9 m/s at 1,000 meters through southwest, 14 m/s, at 2,000 meters, and west-southwest, 14 m/s, at 3,000 meters altitude. The tornado paths were observed to move with the wind above 1,000 meters, i. e., from southwest to northeast.*

The day had been oppressively warm and immense cumulus clouds prevailed during the afternoon. By 7 p. m. the lower clouds had disappeared except in the east in the vicinity of the storm, and the sky was clear except for 0.3 cirro-stratus clouds from the west.

The cloud formation over the storm was watched from Broken Arrow from 6:45 p. m. until darkness. Immense cumulus, boiling up with violent commotion, rose to a great height, above which a veil of alto-stratus spread out to the west or windward side. This view of the storm from the rear under a nearly clear sky afforded an unusual spectacle. The cumulus tops were aglow with the last rays of the evening sun and were brightly lighted at intervals by lightning within the clouds.

It is a singular fact that, although very many people in this portion of the State watched this phenomenon with interest, it was six hours after the disaster at Peggs before the news reached the nearest town from which a call for help could be sent out.—*J. A. Reihle, Broken Arrow.*

* These tornadoes occured about the time of passage of a line of conveyence of wind from the south and west. This line extended in a general northeast-southwest direction through east Texas and Oklahoma.

THE TORNADO AND ITS CAUSE.

By W. J. HUMPHREYS.

[Reprinted from Journal of the Franklin Institute, January, 1918, pp. 114-116.]

The tornado,[1] in which the air travels in approximate circles, as its name implies, is well-nigh peculiar to the United States east of the Rocky Mountains. Nor is it at all equally distributed over even this area, since it occurs rarely in the Alleghenies, seldom along the Gulf and Atlantic coasts, frequently in central and northern Alabama, Georgia, and South Carolina, frequently also in Ohio, Indiana, Illinois, and southern Michigan, and most frequently in Missouri, Kansas, and Iowa.

The tornado develops only in connection with a thunderstorm, usually just in front of the rain, and especially in connection with those particular storms that form along a valley LOW, or between V-shaped isobars where opposing winds of widely different temperatures give rise to that exceptionally strong vertical convection essential to the genesis and growth of the thunderstorm. The season of most frequent occurrence, therefore, is spring and early summer; in fact, during winter it is unknown, except occasionally near the Gulf and in other warm sections. Similarly, the time of most frequent occurrence is 3 to 5 p. m. Also, since it is only a local phenomenon, while the conditions favorable to its genesis are much more extensive, it often happens that a number of tornadoes develop, even close together, in connection with a single distorted cyclone.

The diameter of the tornado averages only about 300 meters (984 feet); the length of its path varies roughly from 100 meters to possibly 500 kilometers (328 feet to 310 miles); its direction of travel is nearly always northeast; its rate of travel, though differing greatly, averages roughly 11 meters per second (25 miles per hour), thus passing a given place in half a minute or less; while its winds, always counterclockwise, are the swiftest known, estimated at 45 to 225 meters per second (100 to 500 miles per hour). It is therefore by far the smallest, briefest, and severest of all storms. Essentially it is a phenomenon of the middle atmosphere. In its genesis clouds whirl around each other with great velocity and turmoil, while from beneath their center a funnel-shaped cloud develops, usually tapering off to a long pendent spout that may or may not extend to the earth. Wherever it does reach the surface it produces a deafening roar, and practically everything in its immediate narrow path that can be blown down or torn to pieces is destroyed, though generally but little damage is done on either side. On the other hand, wherever it does not come to the surface its passage produces but little or no effect.

Cause.—From the characteristics of the tornado and from the meteorological conditions that normally accompany it, it appears that its origin must be purely mechanical. Thus, its rotation obviously is derived essentially from that of the cyclone in which it occurs, since it is always in the same sense counterclockwise, however small its diameter, and never clockwise, as is often the case with large dust whirls when formed in still air. But how is the rapid rotation started? From the directions of the V-shaped isobars it is clear that at the cloud level, say, there must be, as often observed, neighboring winds flowing in approximately opposite directions and, of course, more or less intermingling and overrunning counter currents. Hence, under such conditions, the inflow occurring at various levels that feeds the strong updraft always just in front of a thunderstorm must occasionally so deflect these countercurrents by drawing both into the same rising column as necessarily to produce a violent whirl.

Here, too, as in all other cases of atmospheric motion, the law of the conservation of areas, or the constancy of the product of radius of curvature by linear velocity, applies, except as modified by friction and viscosity. Hence, as the radii of curvature of the opposing currents may at first be comparatively large, and after the deflection relatively small, it follows that the wind velocity within the whirl in which both the countercurrents are taking part may be very great. This rotation, however, does not check the upcurrent, hence that convection which is essential, as explained above, to the rotation, is maintained, and therefore the rising currents brought in spirally with increasing angular and linear velocity as the axis of spin is approached. Each filament, so to speak, of the spirally-rising air viscously drags along its under and slower neighbors, thereby bringing them nearer the axis and increasing their velocity. In this manner the whole of the rising column is set whirling with greater or less spin. Around the axis of rotation the pressure obviously is reduced in proportion to the centrifugal force, the temperature correspondingly lowered, and therefore a cloud spout often formed.

Wherever the inflow of the surface air is greatly checked, or its course so altered by a deflecting hill or other obstacle as greatly to decrease the spin, there the tornado must lift. It may, however, retain its full vigor in the unaffected upper air, and soon reach the surface again.

Why essentially peculiar to the United States.—Since the tornado rarely occurs in violent form except in that portion of the United States which is east of the Rocky Mountains, it follows that that combination of meteorological conditions essential to its genesis seldom obtains in other parts of the world. This combination appears to be very simple—only a vigorous convection between strong neighboring countercurrents. But since vertical convection, as indicated by thunderstorms, is common enough in most parts of the world, it follows that the other factor—namely, strong countercurrents—is the distinctly American phenomenon. That such currents should often occur east of the Rocky Mountains is obvious from the position and trend of these mountains themselves, giving rise to southward winds, and the location of the Gulf of Mexico, from which winds turn northward. No other similar combination of mountain and ocean wind controls exists, and therefore no other place has in all respects the same kinds, frequencies, and intensities of storms.

[1] For detailed discussion see Finley, "Tornadoes," New York, 1887, and Ferrel, "A Popular Treatise of the Winds," New York, 1889.

Principal Publications Containing Statistics of Tornadoes in the United States.

Finley, J. P. Tornadoes. New York. 1887.

Finley, J. P. Character of six hundred tornadoes. (U. S. Signal Service. Professional paper 7. Washington, 1882.) Gives tabulated statistics, with map, showing distribution of tornadoes in the U. S. 1794–1881, incl.

Flora, S. D. Tornadoes in Kansas. (In U. S. MONTHLY WEATHER REVIEW, v. 43, p. 615–617. Washington. Dec. 1915.)

Hazen, H. A. The tornado. N. Y. 1890.

Henry, A. J. Climatology of the United States. p. 76–80. (U. S. Weather Bureau. Bulletin Q. Washington. 1906.

Henry, A. J. Tornadoes, 1889–1896. (In U. S. Weather Bureau Report of the Chief, 1895–96, p. xxiii–xl.)

Tornadoes in the United States in 1916. Annual report, Chief of Bureau, 1916–17, p. xxxiv–xxxviii, and chart 5.

Tornado frequency per unit area. (In U. S. Weather Bureau. MONTHLY WEATHER REVIEW, v. 25, p. 250–251. Washington, June, 1897.)

Property loss by tornadoes during the period 1889–1897. (In U. S. Weather Bureau. Report of the Chief, 1897–98, p. 304.)

Annual Report of the Chief of the Weather Bureau, beginning 1916–17, contains a section giving descriptions of tornadoes in each State during the year.

Numerous descriptions of individual tornadoes are scattered through the files of the MONTHLY WEATHER REVIEW, published by the U. S. Weather Bureau.

Some of the more important of these are:

St. Louis tornado of May 27, 1896. 1896, Mar., **24**: 77–81.

Omaha tornado of March 23, 1913. 1913, Mar., **41**: 396–397; 481–483.

Tornadoes in Kansas. (Summary.) 1915, Dec., **43**: 615–617.

Characteristics of tornadoes. 1899, Jan., **27**: 157.

Wind force in tornadoes. 1901, Sept., **29**: 419.

Tornadoes in eastern Nebraska, April 6, 1919. 1919, Apr., **47**: 234–236.

Tornado at Fergus Falls, Minn., June 22, 1919. 1919, June, **47**: 392–393.

Kansas tornadoes. 1919, July, **47**: 447–484.

Cyclones should not be confused with tornadoes. 1906, Jan., **34**:165.

Climatological Data for the United States by Sections also contains reports of tornadoes.—*C. F. Talman.*

THE HAILSTORM OF APRIL 8, 1920, IN WASHINGTON COUNTY, ALA.

About 5 p. m. on April 8, 1920, a severe hailstorm occurred in southwestern Washington County near Deer Park and Vinegar Bend, Ala. The storm came up with heavy and black clouds and moved from northwest to southeast, and was accompanied by heavy thunder, high winds, and heavy rainfall, amounting to about 2 inches (estimated). The hail fell over a strip about 3½ miles wide to an average depth of about 2½ inches, and drifted in places to a depth of 3 to 5 feet. The hailstones were about the size of a medium-sized hen's egg, egg-shaped and flat. Windows were broken, fruit was knocked off the trees, and leaves of trees, especially of the magnolia, were cut to shreds. The first hailstones that fell were snowy white; later the hailstones became clearer and more angular than when first observed. These details were kindly furnished by the postmaster at Deer Park, Ala.—*P. H. Smyth.*

CLOUDINESS IN NEW YORK STATE.

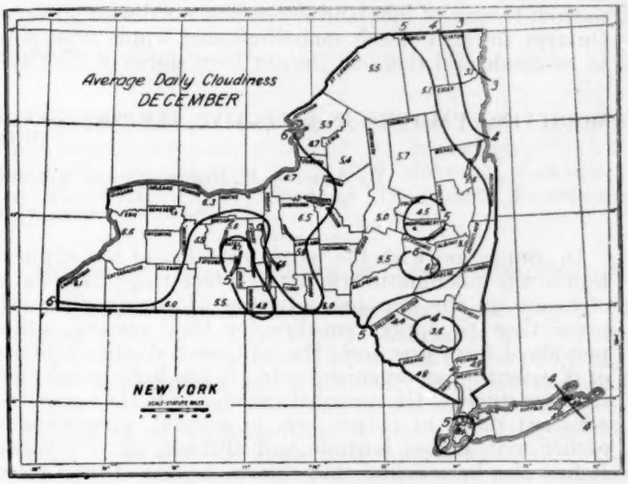
By ERNEST S. CLOWES.

[Bridgehampton, Long Island, N. Y., Apr. 14, 1920.]

With the exception of North Carolina, the State of New York contains a greater range of temperature than any eastern State and it exceeds even North Carolina in the variety of its climatological features. With a seacoast of 250 miles and an approximately equal shore line on the Great Lakes, with elevations varying from sea level to 5,000 feet above, and lying, as it does, in the track of the great majority of storms that cross the American Continent, it offers an opportunity probably unequaled by any similar area in the world for a study of the varied phenomena of weather and climate. In this paper it is only intended to consider the distribution of cloudiness throughout the State as it is typically illustrative of lower cloud formation.

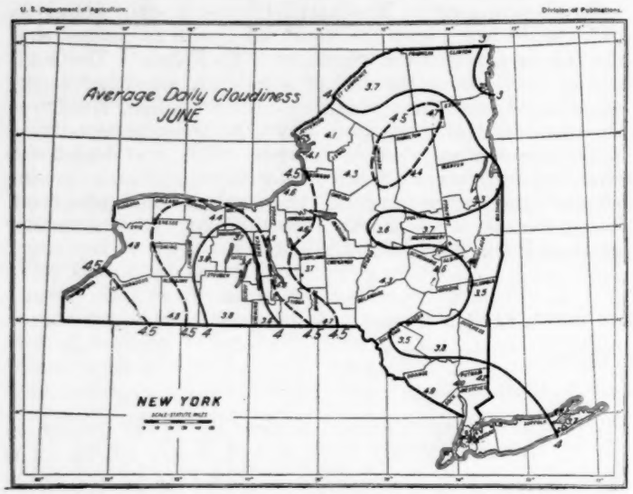
It has long been known that the leeward shores of the Great Lakes are one of the cloudiest regions of the United States, especially during the winter season; and further study goes to show that in all the lake region the cloudiest section is that along the eastern shores of Lake Erie and Lake Ontario where in addition to the situation of a leeward shore is added that of a marked elevation of the land area. At the same time it was recognized that other parts of New York were relatively sunny in winter, and so, in order to partly clear up this rather cloudy situation, this little study was undertaken while the author was at Syracuse, N. Y., in the service of the U. S. Weather Bureau and able to avail himself of the opportunities there offered.

The method employed was as follows: A number of stations, regular and cooperative, were selected with records of clear, partly cloudy, and cloudy days extending back for at least five years. From these records the months of December and June were selected to represent the maximum and minimum of cloudiness, although it is likely that July in some cases would have been nearer the minimum and November to the maximum. A five-year average was then made for each of these stations of the number of clear, partly cloudy, and cloudy days in each of these months. What was most wanted, however, was an expression of the average daily cloudiness. This was secured as follows: As the expression clear means a cloudiness of from 0 to 3 on a scale of 10; partly cloudy from 4 to 7, inclusive, and cloudy from 8 to 10; the average number of clear days was multiplied by 1½, of partly cloudy by 5, and of cloudy by 8½. The sum of the results was divided by 30, giving an expression for average daily cloudiness that was well within the limits of experimental error and which gave a fair basis for comparison. These figures were then inserted on their proper places on the map and lines of equal cloudiness drawn as shown. A contour map of the State with lines drawn at 500, 1,000, and 1,500 feet was also prepared.



Let us first look at the December map. The area of greatest cloudiness covers the entire western half of the State except for a "hump" of relatively clear skies from the southern boundary to the neighborhood of Rochester. Within this "hump" is an oval area covering the counties of Yates, Schuyler, and Chemung with an even less degree of cloudiness; 20 to 30 per cent less than in the section 50 miles to either side. This cloudy belt of western New York is, of course, explained by the prevailing northwest winds rising from the lakes to the high land of the interior which at this season is much colder than the water surface. The relatively clear spot in the

west-central section can be explained by a glance at the contour map where it can be shown to coincide fairly well with a tongue of relatively low land running down from Lake Ontario and bounded on either side by land 500 to 1,000 feet higher. This is the region of the "Finger Lakes." The eastern half of the State, while on the whole much less cloudy than the western, shows maxima and minima clearly influenced by the



land elevation. For example, the clearest section is the west shore of Lake Champlain under the lee of the Adirondacks with an approach to it in Ulster County under the lee of the Catskills and the high plateau to the west; while the cloudiest spot in the eastern half of the State seems to be Schoharie County, at the end of a narrow trough of low land extending northwest to Lake Ontario through which moisture-laden winds may pass to be condensed there on the northern slopes of the Catskills. The relatively high cloudiness around New York City is probably local and due to city smoke and sea fogs or those arising from the harbor, which are at the maximum at about this time.

Turning to the June map we find much greater uniformity throughout the State, owing to the facts that the northwest winds from the lakes are more rare and that the land surface is warmer, but the minima over Lake Champlain and west-central New York still persist, although in not so pronounced a form. The influence of the mountains is still shown, and a new minimum has appeared in eastern Long Island. This last is probably due to causes mentioned in the author's earlier paper on the climate of this region published in Climatological Data for New York in 1917, viz, that this region is on the edge of the cloud belt resulting from St. Lawrence Valley storms, which are the prevalent summer type, and to the relative infrequency of thunderstorms, due to the proximity of the ocean and the trend of the coast which tends to keep the temperature low and uniform.

These maps show quite clearly the relation of wind, large water surfaces, and land elevation to cloudiness. Further study would probably show a correspondence with rainfall, and especially snowfall, as it is well known that the southeast shore of Lake Ontario is one of the snowiest regions of the United States.

AMATEURS RECEIVE FORECASTS BY WIRELESS TELEPHONE.

A letter from Mr. Eric R. Miller, of the Weather Bureau station at Madison, Wis., states that the Physics Department of the University of Wisconsin has for several months been sending out at 10 a. m. the weather forecast for Wisconsin. The wave length is 1,000 meters. Plans are under way to supply this information by wireless telephone. The apparatus is powerful enough for the messages to be audible to amateurs throughout the southern half of Wisconsin.

MODIFYING FACTORS IN EFFECTIVE TEMPERATURE; OR, A PRINCIPLE OF MODIFIED THERMAL INFLUENCE ON ORGANISMS.[1]

By ANDREW D. HOPKINS, Forest Entomologist in Charge of Forest Insect Investigations.

[Bureau of Entomology, United States Department of Agriculture.]

In connection with the writer's studies of the application of the bioclimatic law to the forecasting of the dates of events in the seasonal activities of insects, the optimum time to apply remedies for their control, other periodical farm practices, the latitude and altitude limits of distribution of organisms, etc., it has been found that the departures of the recorded variable from the computed constant dates of events are, in general, progressively earlier with higher latitude and altitude, or vice versa. It has also been found that certain regions of the United States are characterized by later departures, while the reverse is true of other regions.

According to the laws of temperature control of the seasonal activity of organisms, it has been assumed that a temperature above 45° to 50° F. is required to stimulate activity or that a given accumulation or sum of heat above the effective is required for the development of seasonal events.

It would seem, therefore, that an explanation of the regional departures might be found in the prevailing temperature, but an effort to apply this principle led to confusion rather than to an explanation of the causes of such variations.

It is natural to assume that acceleration of activity, represented by an early departure from the constant, would be associated with a relatively higher temperature, but when the mean temperatures of the regions of uniformly early or late departures were studied it was found that, as related to the major regions, progressively higher mean temperature with lower latitude and altitude was associated with progressively later departures, and vice versa.

It is plain, therefore, that, while temperature is an important factor of control, there are other factors that modify its effective influence which are related to latitude, longitude, and altitude. It seems (as indicated by the writer in SUPPLEMENT 9 of the MONTHLY WEATHER REVIEW, 1918) that the amount and character of daylight, sunshine, etc., exert an important modifying effect on life activities and that this effect is not reflected in the recorded temperature. It would appear, therefore, that it is in the variation of the effective influence of light, and evidently other elements of climate, with varia-

[1] Presented before American Meteorological Society, Washington, D. C., Apr. 22, 1920.

tion in geographical position, that we are to find an explanation of the modified effects of temperature.

The results of recent investigations on this theory seem to warrant the recognition of a principle of modified thermal influence which is intimately related to the principles on which the bioclimatic law is founded.

In an effort to determine a gradient or unit constant by means of which the intensity of this modifying influence, *from whatever cause*, could be measured and computed, it was found that a general average rate of 0.25° F., or its equivalent of one day in time, for each 1° isophane and 400 feet of altitude could be utilized for correcting the recorded thermal means or the computed date constants for any given geographical position so that there would be a reasonably close agreement between the cause as represented by the modified temperature and the effect as represented by the recorded date of an event.

In comparing the departures of the recorded from the computed dates of events in the different regions by the modifying method it was found that, in general, the regional departures, as determined by the usual method, were accounted for. It must not be expected, however, that anything but the general regional influences can be interpreted by this method because it can not provide for the topographic and other influences which are reflected in the local departures.

There is need of further investigations of the problems relating to this proposed principle and it is hoped that they will receive due consideration by meteorologists as related to the laws and principles of temperature, light, etc., and by biologists and physicists as related to the practical application of the principle in their investigations of the responses of organisms to the influences represented by temperature and other elements and that there will be cooperation in the investigations of the relations of causes and effects.

It appears, however, that the present state of information on the coordinate relation of thermal unit constants to the other unit constants of the law will justify a revision of the first table of coordinates[2] as related to (*a*) latitude, longitude, and altitude, and (*b*) the isophanes and altitude, as follows:

Tables of geographic coordinates and unit constants of the bioclimatic law.

(*a*) FOR LATITUDE, LONGITUDE, AND ALTITUDE.

Coordinates.	Unit constants.				
				Modifying.	
Geographic.	(*a*) Geographic.	(*b*) Time.	(*c*) Thermal mean.	(*d*) Thermal.	(*e*) Time.
			°F.	°F.	
1. Latitude	1°	4 days	1	0.25	1 day.
2. Longitude	5°	do	1	.25	Do.
3. Altitude	400 feet	do	1	.25	Do.

(*b*) FOR ISOPHANES AND ALTITUDE.

Coordinates.	Unit constants.				
				Modifying.	
Geographic.	(*a*) Geographic.	(*b*) Time.	(*c*) Thermal mean.	(*d*) Thermal.	(*e*) Time.
			°F.	°F.	
1+2. Isophane	1°	4 days	1	0.25	1 day.
3. Altitude	400 feet	do	1	.25	Do.

[2] Journal of the Washington Academy of Sciences, Jan. 19, 1920, p. 38.

CLIMATIC CONDITIONS IN A GREENHOUSE AS MEASURED BY PLANT GROWTH.[1]

Climatic conditions are usually stated in terms of temperature, rainfall, percentage of sunshine, relative humidity, etc. A few attempts have been made to measure such conditions in terms of plant growth. In one of these experiments the climatic conditions of a greenhouse were expressed as rates of certain definite plant processes. The experiment was carried out (1916–1917) in one of the greenhouses of the Laboratory of Plant Physiology of the Johns Hopkins University at Baltimore, Md. Buckwheat seedlings of approximately the same size and from the same stock of seed were grown for a series of 4-week exposure periods over a total time period of 13 months. Such culture plants were considered the instruments for measuring the climatic conditions as these affected the plant processes. Values representing the process of dry-weight production, leaf-area increase and transpirational water loss increased during the spring and decreased during the autumn with maxima in summer and minima in winter. The rates of stem elongation, however, showed remarkably low values for a period about the summer solstice. Approximate indices of efficiency of these climatic conditions in this particular greenhouse to favor these plant processes may be briefly stated in relative numbers for each calendar month as follows:

Month.	Stem height.	Dry weight.	Leaf area.	Transpiration.
January	0.64	0.13	0.20	0.11
February	.70	.27	.35	.24
March	1.03	.61	.63	.63
April	1.30	.90	.84	.87
May	1.34	1.00	.95	.96
June	1.00	1.00	1.00	1.00
July	1.30	.94	.91	1.00
August	1.46	.81	.79	.95
September	1.40	.61	.63	.69
October	1.14	.39	.49	.40
November	.92	.22	.37	.24
December	.76	.15	.27	.15

The approximate annual ranges (ratio of maximum to minimum) were: Stem height, 2; dry weight, 8; leaf area, 5; transpiration, 9.—*Earl S. Johnston, Laboratory of Plant Physiology, Maryland Agricultural Experiment Station.*

THE DISTRIBUTION OF MAXIMUM FLOODS—DISCUSSION.

We have received a letter from Mr. H. R. Leach, of Saginaw, Mich., commenting on the paper by Prof. A. J. Henry upon "The Distribution of Maximum Floods," which appeared in the December, 1919, REVIEW and calling attention to the following points: (1) That true comparison of the magnitude of floods occurring in different years can be made only by comparison of the volume of flow, and (2) that at some of the Weather Bureau gages known to him the zero of the gages are not referred to a fixed plane of reference, and he gives two examples which will be referred to later.

The first point made by Mr. Leach is well taken, but since discharge measurements are not available, recourse was necessarily had to gage heights.

With reference to the second point: In establishing new gaging stations, the uniform practice of the Weather Bureau during the last 8 or 10 years has been to set the zero of the gages to correspond with the bottom of

[1] Author's abstract of paper presented before American Meteorological Society, Washington, D. C., Apr. 22, 1920.

flowing water in the stream; in cases of replacement of old gages, the zero of the old gage has been continued without change.

A considerable number of river gages now used by the Weather Bureau were installed by other branches of the public service—the Army Engineers, the Mississippi River Commission, the U. S. Reclamation Service, and the U. S. Geological Survey. Almost without exception the original zeros have been continued. The gage at Yuma referred to by Mr. Leach is a case in point. The Weather Bureau is using the gage established by the U. S. Reclamation Service, and in order to prevent confusion a note is printed in each volume of Daily River Stages to the effect that stages at that station do not indicate the volume of water in the river. In the case of Umatilla, on Columbia River, that station was established by the Army Signal Corps in 1878 and the zero was placed to correspond with low water of 1874.

In the early days of gaging rivers in this country it was a common practice to refer the zero of the river gage to the lowest known water for the gaging station.

It should be remembered that the object of Weather Bureau river gagings is primarily to secure data on which to base flood forecasts and that the gagings do not and are not intended to indicate the volume of water in the stream. It is, of course, to be regretted that it was not foreseen that the selection of arbitrary points of reference for the zero of the gages would lead to complications in the future.

SOME METEOROLOGICAL OBSERVATIONS OF A BOMBING PILOT IN FRANCE.[1]

By THOMAS R. REED, Meteorologist.

SYNOPSIS.

Smooth flying is generally found above cloud summits in summer, and bumpy air beneath them. Exceptions to this rule were so rare in the writer's experience on the western front during the summer of 1918 as to be worthy of note, and one such exception was made the subject of memoranda on the occasion of its occurrence. This was on the afternoon raid of August 29, 1918, in connection with the Oise-Aisne operations, when roughness was found at all levels. The cumuli that occupied the lower levels were left far below, but roughness was still encountered, although an altitude of 5,000 m. was reached before the lines were crossed. Phenomena, associated by the writer with the disturbed conditions in the upper air, were noted later in the appearance of cirro-stratus clouds overhead, the remainder of the journey to the objective being made between two cloud-strata—cirro-stratus above, cumulus and strato-cumulus beneath.

The term "bumpy weather" has come into such general use among aviators that it has ceased to be slang and become a proper part of aeronautical parlance. No other term expresses so succinctly the presence of atmospheric disturbances arising from convection and topography, the commonest sources of those localized turbulences that affect the piloting of airplanes. Although frequently employed by flyers in referring to undulatory movements or air swells of any kind, the conditions to which the expression specifically applies are more often attributable to convection and topography than to anything else.

Convection, of course, is most active in summer, or the warm season, while topographic influences are more likely to be felt in the winter or during the season when horizontal air currents are strongest. The height to which an uneven landscape may extend its influence depends on the ruggedness of the surface and the speed of the wind passing over it. In general a few hundred or a thousand meters of elevation will smooth out the irregularities arising from this cause, while convectional irregularities are often found in their greatest vigor at that height or above.

Pilots who were on the west front in the summer of 1918 and stayed in action until the armistice had an excellent opportunity to experience both these conditions in their most typical forms, particularly if they were engaged in the American sector where the terrain was notoriously broken. During the warm season convectional disturbances were very active, and raids were executed almost daily in spite of weather conditions. It was no unusual thing for the writer's escadrille (Breguet No. 128) to leave the Roissy airdrome on a raid during the Oise-Aisne operations when the sky was almost filled with the cumuli of an impending storm. Under such circumstances it was customary for the commandant who led the group to take us above the clouds, for although the interstices in the latter might afford only scanty vision of the landscape, and navigation therefore be difficult, the group was less liable to attack, and the problem of managing the planes and keeping a good formation was greatly simplified. The bumps were left below and we had an undisturbed medium in which to perform the journey.

Flying in group, though never employed in peace times, except for exhibition purposes, is of first importance in war, and all branches of the flying corps, whether pursuit, reconnaissance, or bombardment, must employ it on occasion or be exposed to successful attack by lurking enemy planes.

Formation flying brings home to the pilot more forcibly than any other form of air work the fickleness of his atmospheric medium. This is because the sense of motion is so purely relative that unless one has some object close at hand with which to relate his course he soon loses consciousness of his own speed, and is quite oblivious to the factor of wind velocity (and, to some extent, of direction) so long as exerted in the plane of his own movement. Even undulatory movements are not realized unless abrupt, especially if one is flying with the wind.

Vertical currents, of course, are evident enough under any circumstances, but until one finds himself flying in a group and trying to maintain a certain position with respect to other planes close at hand he does not accurately estimate all the components of movement that are agitating the air.

The greatest obstacle to formation flying is convection. The plane does not always rise or sink on an even keel, as might be supposed; more often it is pitched this way and that, one wing now up and the other down. The sensation under a thunder cloud is exactly that of an antiaircraft bomb exploding underneath you, with the difference that you don't get any shrapnel holes in the process.

Every meteorologist knows theoretically, and every pilot from experience, that bumps generally are found in and under (at least close under) cloud formations, and smooth flying above them. In an arid region one would feel the currents of convection without the attendant clouds to define their limits. Not so in France. Here clouds formed so readily that the presence and strength of vertical currents might oftentimes be safely gaged by their visible outlines, the character of the summer cumuli serving as an excellent indicator of the roughness of one's projected flight. We knew that flying below them

[1] Presented before American Meteorological Society, Washington, D. C., Apr. 22, 1920.

would mean a tussle with aileron and rudder to keep on an even keel; but that once their snowy summits were passed the fight would end and that the big bombers would glide on their way as if on a glassy sea. Exceptions to this rule were unusual enough to draw out a good deal of comment when they occurred. An excellent example of such an exception was found on the afternoon raid of August 29, 1918.

Two raids were made on that day, one in the morning and another in the afternoon. In the morning, although thunderheads were forming and we had the customary bumpy weather until they were surmounted, the usual placidity was found above. The clouds had increased by afternoon and it was so rough that only four planes out of the original 10 that started remained in the air, the others turning back before they had climbed a thousand meters. The remaining four stuck together, thinking to get through the clouds to the calm above, and the appearance of another escadrille overhead, which we joined a few minutes afterwards, encouraged us in this idea.

It is pretty work getting a formation through the clouds, requiring much twisting and turning to rise through the holes to the blue above, judgment on the part of the leader, who must guard against sharp turns or running into a cloud, and vigilance on the part of the pilots, who must keep their position and avoid collision, while being tossed about relentlessly in the upward surging and restless air.

Expectation of finding smooth sailing in the upper air, however, was not realized on this occasion. Although the region of cloud was left far below—so far that the once imposing masses of mountainous white had lost their individuality and seemed merged in a sea of petty billows—we were still encountering undulatory currents and of so marked a nature that in my notes on the raid, set down immediately afterwards, I have referred to them as bumps. In winter we might have expected overlapping currents and consequent roughness at any altitude, but to find them in midsummer and at 5,000 meters was extraordinary, and in my personal experience distinctly worthy of note. My meteorological training naturally led me to look for some development which would visibly attest the extra-local character of what was going on, so I was not surprised when cirrus clouds began to appear overhead in what had been a sky of unobstructed blue. Before the lines were reached we were sailing between two cloud strata,—a rapidly thickening cirro-stratus veil above, cumulus and strato-cumulus beneath.

The weather map for this date did not reveal any marked cyclonic developments. The barometer was high in western Europe and relatively low over the Baltic regions. The map for August 30, however, the day after our raid, bore evidence of a different character. It showed a fall in pressure over northwestern Europe and indicated the approach of a disturbance to the north of Scotland, an augury confirmed by the chart of August 31, which depicted a typical depression central in the North Sea and causing unsettled, rainy weather throughout the British Isles, the Netherlands, and northern France.

When the group moved eastward in September to take part in the Meuse operations of the 1st American Army, opportunity was afforded of doing cross-country work over a very different type of land. It was much more hilly; in fact, there was so little level or cleared ground that airdrome sites in the region around Bar le Duc, where many squadrons were clustered, were difficult to find. Flying over such a country, if it was at all wind swept, gave a pilot plenty of work to do at low elevations, especially if he were flying one of the larger types of plane. The greatest uncertainties, of course, were involved in landing. Coming to earth at express-train speed is a matter of nicety even with everything in one's favor, but to do it day in and day out on fields remarkable only for their uneveness and limited extent gives one ample familiarity with the fickleness of surface currents when distorted by irregularities of the terrain.

The plane may be almost seated, wheels and tail skid about to brush the earth, when a puff catches the ship and lifts it into the air again or tilts it sidewise, calling for the quickest action from the pilot to avert a stripped undercarriage or a scraped wing. Sometimes the only thing to do is to put on the motor and circle the field for another landing.

As regards the consideration of safety, no danger is to be feared from air bumps so long as the pilot enjoys sufficient altitude in which to maneuver. He may be tossed about and even thrown into a slip, but, given enough space and a properly lined-up ship, he can recover himself and maintain flight even under the most boisterous conditions of wind and weather. His difficulties await him as he approaches the earth. For this reason rolling ground never should be chosen for a permanent landing field. The necessities of war require the use of whatever flying fields can be found; but in the case of civilian flying, the selection of such fields should be a matter of the most careful judgment, so that the danger of accident from the principal uncertainty of present day aviation may be reduced to the minimum.

DISCUSSION.

The condition of bumpiness above, as well as below, cumulus clouds in the forward part of a cyclone may be explained as follows:

The southerly wind of the front of a cyclone rides under the upper portions of the remains of the westerly or northwesterly wind which the southerly wind has displaced at the lower levels. This upper wind is likely to be cold, whereas the lower, southerly wind is likely to be warm. During the first day that the southerly wind blows the continued fall in temperature of the upper current and the rise in temperature of the lower one frequently produces a temperature gradient which exceeds the adiabatic, and thus establishes convection between the two winds. As the difference in temperature increases, the depth of the convective layer of adjustment increases until its under boundary may reach the top of the layer of surface local convection marked by cumulus clouds. n the case described, the upper convective layer does not seem quite to have reached the lower one; if it had, the cumulus clouds would have extended rapidly to the top of the upper convective layer and gone beyond.

Mr. J. C. Edgerton, in his fully kept meteorological logs of his daily postal mail flights from Washington to Philadelphia and return in the summer of 1918, mentions several times the occurrence of "bumpy weather" in the lower levels and at intermediate levels in the morning, but very bumpy conditions from the ground to great heights in the afternoon.

When alto-cumulus clouds are visible when a southerly wind is blowing at the surface, they probably mark the top of the higher bumpy layer, just as the cumuli summits mark the top of the lower.—*Charles F. Brooks.*

METEOROLOGICAL CONDITIONS AFFECTING AVIATION IN MESOPOTAMIA.

By C. W. B. NORMAND.

[Abstracted from note in Quar. Jour. Roy. Met'l. Soc., October, 1919, pp. 368-379.]

This paper consists chiefly of a brief discussion of the meteorological conditions of this portion of Asia Minor, such as the general pressure distribution, temperatures at the surface and aloft, and prevailing winds. The winter weather of this region falls under the domination of an offshoot of the central Asian anticyclone, while in summer the dominant factor is the great low-pressure area which lies over southern Persia and Baluchistan. As to temperatures, it is found that the annual range at Bagdad is rather large. The highest temperature ever recorded was 122.8° F. and the lowest was 18.6° F., giving a range of 104.2° F. Objects exposed to the sun may exceed the air temperature by as much as 40° F. Practically nothing is known of upper air temperatures, except that which was observed by kite-balloon companies operating in that region during the war. The prevailing surface wind is northwest and southeast in winter and spring, and in summer the prevailing wind is from between north and west. Aloft, the frequency curves for the whole year show that northwest is by far the most persistent direction to heights of 9,000 feet. There is a tendency, however, for the winds to become westerly at the upper levels. The annual variation of wind velocity is such that there is a maximum in July and a minimum in November. The strong northwest wind of June, July, and August, called the Shamal, is very persistent and raises great dust storms.

The curves showing the variation of wind velocity with height indicate a maximum at about 1,000 feet above the surface. It is found that often a gentle wind at the surface in the early morning may be overrun by a strong wind at a height of 400 feet. As soon as convection starts, the wind above increases the speed of the surface wind, with the result that a dust storm, which may last all day, is produced. An aviator must take cognizance of this fact or he may ascend in early morning and before he is aware of it, the ground will be blotted out by rolling clouds of dust which practically prevent a safe descent. Bumpiness, under such conditions of extreme surface turbulence and convection, is the rule. The so-called "dust devils" (dust whirls), of that region have been observed at 6,500 feet above the surface.

Fog, cloud, and rain are very rare, especially during the summer months, although clouds and fog occur occasionally in winter. At Bagdad, Basrah, and Babylon there are only 26 rainy days per year. Snow, of course, is extremely rare and occurs once in 10 years, as a rule. Aircraft are subject to damage from thunderstorms and hail in March and April. Hailstones 1¼ inches in diameter have been observed. The author concludes his note with the following summary:

"From the point of view of weather 'Iraq should afford more flying days than Britain, though it does not offer as ideal conditions as Egypt. The annoyances and risks which the weather of 'Iraq offers to aviation are the extremely high temperatures during the day in hot weather causing engine trouble; the occasional risk to the early morning flyer of finding a dust storm raging by the time he wishes to descend; rain and low clouds from November to April; fog in December and January. It should be noted that the nearer an aerodrome is to the Persian hills the more rainfall will it receive."—*C. L. M.*

SOME OBSERVATIONS OF THE UPPER AIR OVER PALESTINE.[1]

By Capt. A. J. BAMFORD.

[Abstract reprinted from Nature (London), Dec. 4, 1919, p. 364.]

This paper gives a brief summary of some upper-air observations made in Palestine during the last two years. Tables and graphs are given showing the monthly averages of the horizontal movements at different altitudes over three stations, at one of which (near Ramleh) observations were kept up continuously for a year. The second part of the paper deals with vertical velocities, and includes frequency curves, showing for each of the layers 0–2,000 feet, 2,000–4,000 feet, and 4,000–6,000 feet, the number of times in each month that the observed velocities differed from the theoretical ones by not more than 10, 20, 30, or 40 per cent, etc. The lowest layer is appreciably the most varied, and in it differences of 50 per cent are not unusual, although the average velocity differs very slightly from theory. In the other layers there is a distinct increase in the compactness of the frequency curves, while the average velocity changes from slightly above to slightly below the theoretical value.

[1] Quar. Jour. Roy. Met'l. Soc., January, 1920, pp. 15-33. Another abstract of this article appeared in Symons's Meteorological Magazine, December, 1919, pp. 133-134.

NOTES, ABSTRACTS, AND REVIEWS.

DEATH OF PROF. FRANK WALDO.

Prof. Frank Waldo, meteorologist and educational expert, died at his home in Boston, Mass., on May 7, 1920. Prof. Waldo was born at Cincinnati, Ohio, November 4, 1857, and graduated from Harvard University in 1884. He was employed as computer and professor in the meteorological branch of the U. S. Signal Corps from 1881 to 1887, and as special agent of the U. S. Weather Bureau in 1890. He was engaged in cattle ranching 1896–1902; editorial work, 1902–1907; was employed as an expert in industrial education by the Massachusetts Commission on Industrial Education, 1907–1911; was a member of the Austrian and German meteorological and philosophical societies and of the National Society for the Promotion of Industrial Education; also of the Authors and Century clubs of Boston. Was the author of Modern Meteorology, 1893; Elementary Meteorology for Schools and Colleges, 1896; and numerous scientific memoirs, reports on industrial education, and articles on popular science.—*H. E. Williams.*

PRINCIPAL METEOROLOGICAL WRITINGS OF FRANK WALDO.

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—*C. F. Talman.*

THE RETIREMENT OF SIR NAPIER SHAW.

[Reprinted from Nature, Apr. 1, 1920, pp. 144–145.]

The impending retirement of Sir Napier Shaw, who has been Director of the Meteorological Office since 1905, and as president of the International Meteorological Committee, occupies a unique position, marks an epoch in the history of British meteorology. Trained primarily as a physicist, Sir Napier has been able to approach meteorological problems in a scientific spirit. His academic experience brought him into contact with younger men, and by the encouragement he extended to them he raised the level of his subject. As a consequence, there are at the present moment a greater number of men in the British Empire capable of dealing with intricate meteorological problems than in any other part of the world. A heavy responsibility rests on the authorities on whom the duty of nominating Sir Napier's successor falls. When the Meteorological Office was taken over by the Air Ministry last year the change was looked upon with grave misgivings. The near future will show whether the anxiety then felt then regarding the wisdom of a step that was taken against the advice of all competent authorities is to be relieved or intensified. It would be an irretrievable calamity if administrative rather than scientific qualifications were to determine the choice. Unless the whole future of British meteorology is to be jeopardized, the Director of the Office must be a man of high scientific standing who will maintain the leading place which the Office now takes among the nations of the world. For the credit of the nation and in the interests of science we trust that the new Director will be a worthy successor of the one who has given so much scientific honor to the post.

RETIREMENT OF H. HARRIES.

[Reprinted from Monthly Meteorological Charts of the North Atlantic Ocean, June, 1920.]

Mr. H. Harries retired on 31st of March, 1920, after 45 years' service at the Meteorological Office.

Serving first under Capt. Toynbee, then under Capt. Campbell Hepworth, Mr. Harries eventually took charge of the Marine Division at the latter officer's death in February, 1919, and so had the unique experience of being the only landsman who has ever acted as Marine Superintendent at the Meteorological Office.

He realized that to deal successfully with the many problems connected with marine meteorology, it was desirable to have first-hand experience and knowledge of the sea, and to understand sailors. With this in view he made several voyages across the Atlantic and to the Mediterranean. He was for a time transferred to the Forecast Division in order that practical knowledge of Atlantic meteorology should be used in forecasting.

Amongst the work done by Mr. Harries, which is of special interest to seamen, was the drawing of the Monthly North Atlantic Meteorological Charts during the first two years of their issue. He designed and prepared maps of hourly tidal streams round the British Isles, which were first published by the Admiralty in the form of a pocket atlas.

Mr. Harries has recently contributed a series of articles on North Atlantic synoptic meteorology on the October, 1919, to January, 1920, Monthly North Atlantic Meteorological Charts, and just before retiring prepared an article on cyclones of the Arabian Sea and Bay of Bengal, in which he shows how the seaman may be misled by following the usual rules which are applicable to these storms in other parts of the Tropics; May, 1920, Indian Ocean Chart.

THE METEOROLOGICAL MAGAZINE.

[Reprinted from Nature (London), Mar. 18, 1920, p. 83.]

The Meteorological Magazine, an official publication of the Meteorological Office, was first issued under its new title about the middle of February. The journal incorporates Symons's Meteorological Magazine and the Meteorological Office Circular. For convenience in reference, the serial numbers of Symons's Meteorological Maga-

zine are being carried on. The change has come about through the absorption of the British Rainfall Organization in the Meteorological Office. The cover of the new publication gives the portraits of four pioneers of meteorology, all of whom were associated with the Meteorological Office. Of these Admiral FitzRoy had charge of the Office at its initiation, when it was a branch of the Board of Trade, and Mr. Symons was an assistant 60 years ago, but left after a short period and devoted himself to the collection of rainfall returns, from which evolved later the British Rainfall Organization. Gens. Sabine and Strachey were, successively, chairmen of the Meteorological Office when controlled by the Royal Society. Little change has been introduced into the style and character of the publication, and it is evidently not intended to make any radical alteration. In addition to the interesting article on "Weather in the British Isles" for the preceding month, which has hitherto regularly appeared in Symons's Meteorological Magazine, an article is now given on "Weather Abroad" which will doubtless be valued by readers of the journal.

DIFFUSION OF LIGHT BY RAIN, CLOUD, OR FOG.

By A. MALLOCK.

[Abstracted from Proceedings of the Royal Society, ser. A, vol. 96, pp. 267–272.]

This paper considers the diffusion of light by particles whose linear dimensions are large relative to the wave length of light. If a source of light is placed within an indefinitely extended cloud which is composed of perfectly transparent small spheres, there is a certain distance beyond which none of the direct rays from the source is received. In this case each drop acts as a separate source of light and diffuses such light as it receives uniformly in all directions. The author defines his "proof plane" as the brightness of a perfectly white plane surface which could be substituted, at the same distance, for the plane in which the perfectly transparent spherical drops are located; for, "since the total quantity of light passing through every spherical surface about the source is constant, it is clear that the illumination will vary inversely as the square of the distance from the source."

It is pointed out that the difficulty of seeing things through a stratum of cloud is not due to loss of definition, but to diffusion and the consequent lack of contrasts between light and shade. This is shown by the perfect definition of the sun through a layer of cloud which really cuts down the light to a great degree by diffusion.

A table is prepared showing the effect of a shower or cloud layer in diffusing the light from a distant source. The following terms were tabulated:

c, the diameter of the drop.

n, the number of drops in a volume a^3 required to diminish by one-half the directly transmitted light.

l, the length of a column of the cloud of section a^2 which contains n drops.

N, the number of drops per unit volume of the clouds.

D, the average distance between drops.

This table was calculated on the basis of the water content in volume a^3 of the cloud being 1/100,000, which at first was thought to be a reasonable estimate. From the results of the table and certain studies in the rate of rainfall, it is believed that this value has been overestimated and that, in the case of falling rain, the volume of water can not form anything like 1/100,000 of the total volume.

TABLE 1.

c.	n.	l.	N.	D.
Inches.		*Inches.*		*Inches.*
0.1	100	10,000	0.01	4.6
.08	164	8,000	.0204	3.65
.06	285	6,000	.0475	2.71
.05	400	5,000	.080	2.32
.04	625	4,000	.156	1.82
.02	2,500	2,000	1.25	1.045
.01	10,000	1,000	10	.483
.008	16,400	800	20.5	.365
.006	28,500	600	47.5	.275
.005	40,000	500	80	.232
.004	62,500	400	366	.140
.002	250,000	200	1,250	.092
.001	1,000,000	100	10,000	.022

"The case is rather different for fog and mist * * *, but even when a fog is so dense as to make a street lamp only just visible at a distance of 10 feet (the densest white fog in my experience) it will be found that either the drops must have been much less than a thousandth of an inch in diameter or that Q [the volume of water content] much less than 10^{-5}." The "proof plane" referred to above was used in calculating l in the table.—*C. L. M.*

Discussion.—It may be of interest in connection with the above abstract to give the size of the drop to be found in various kinds of precipitation. Further data on this question was published in the MONTHLY WEATHER REVIEW, October 1, 1919, page 722. Adopting the same general classification of type of precipitation as is presented in that note, the diameters of the drops average about as follows: Fog, 0.01 mm.; mist, 0.1 mm.; drizzle, 0.2 mm.; light rain, 0.45 mm.; moderate rain, 1.0 mm.; heavy rain, 1.5 mm.; excessive rain, 2.1 mm.; cloudburst, 3.0 mm. to 5.0 mm. These values show the correctness of the author's conclusion in spite of the fact that he was not familiar with these computations.—*W. J. Humphreys.*

LIGHT SCATTERING BY AIR AND THE BLUE COLOR OF THE SKY.

By R. W. WOOD, Professor of Experimental Physics, Johns Hopkins University.

[Author's summary.][1]

1. The intensity of the light scattered by a given thickness of dust-free air in a tube illuminated by concentrated sunlight has been compared photometrically with the light of the sky by reducing the intensity of the latter until a match was secured. The ratio of the two intensities was compared with the calculated ratio, making certain assumptions in the case of the light of the sky and a fair agreement found.

2. The intensity of the light scattered by dust-free air nearly in the direction of the incident light has been examined and found to be not very different from the intensity scattered in a perpendicular direction. It is theoretically twice as bright, but the conditions of the experiment did not permit of the determination of a difference of this amount. This indicates that the enormous increase in the intensity of the sky close to the sun's limb (over twentyfold) results from diffraction by motes in the air, and would be wholly absent if the atmosphere were perfectly clean.

3. The scattering power of the air near the ground on the clearest days in the country has been found to be about 2.6 times the average scattering power of the atmosphere.

[1] Reprinted from the London, Edinburgh, and Dublin Phil. Mag., London, April, 1920, sixth series, vol. 39, No. 232, p. 433.

THE ANNUAL AND GEOGRAPHICAL DISTRIBUTION OF THUNDERSTORMS AND SQUALLS ON THE NORTH ATLANTIC AND ADJACENT COASTS.

By W. KÖPPEN.

[Abstracted from Annalen der Hydrographie und Maritimen Meteorologie, 46: 64-78 1918.]

By means of dividing the Atlantic Ocean into squares of latitude and longitude and noting from ships' logs the frequency with which thunderstorms and squalls were observed in each, the author has obtained a very large quantity of data which is probably quite accurate. The tables presented are elaborate and it must suffice merely to mention the results. For thunderstorms, in the northerly latitudes, for that portion of the Atlantic lying between France and Newfoundland, the greatest frequency occurs in the winter on the eastern side of the ocean and in summer on the western side. Off the African coast, the frequency is also greater in winter and spring than in summer and fall. In the equatorial regions between the South American and African coasts the maximum shifts from autumn through winter to spring as the Equator is approached. At Lat. 16° N., Long. 25° W., the maximum occurs in September; following the same meridian southward, we find the maximum in November at Lat. 9° N., in December at 5° N., and in March and April between 3° N. and 1° S. latitude. Comparisons are made with the frequency on adjacent coasts, and it is found that on the northern European and North American coasts the maximum occurs in midsummer, in southern Europe and Asia Minor the maximum tends toward the autumn.

The maximum squall frequencies occur in the fall, winter, and spring months, shifting from fall through winter to spring with progress southward.—*C. L. M.*

WIND CIRCULATION AS A BASIS FOR FORECASTING THE LOCATION OF PRESSURE AREAS.

By G. REBOUL and L. DUNOYER.

[Abstracted from Comptes Rendus, Paris Academy, Mar. 3 and 24, 1919, pp. 457-459 and 621-623.]

In these two articles, the first entitled *Sur la prévisions des variations barométriques: vents d'appel pour les dépressions*, and the second, *Sur les actions mutuelles des basses pressions et des hautes pressions*, the authors present rules for the forecasting of the location of low and high pressure areas, by means of areas of winds which blow contrary to the normal circulation about such centers. These winds are called, in order to make clear the meaning of their use, "call winds" (*vents d'appel*) or winds which "call" the center of pressure upon the region over which they are blowing. The two rules which have been deduced are:

1. When there is in the vicinity of a depression a zone of winds which blow sensibly parallel from the interior of the depression, and in particular from its center, that depression is called onto the region covered by such winds.

2. When there is in the vicinity of a high-pressure area a zone of winds which blow sensibly parallel toward the interior of the area, this area is called onto the region covered by such winds.

A more definite idea of what is meant by *vents d'appel* is given by the example of a northerly wind over France which appears to be within the domain of the Iceland LOW but is really caused by the LOW on the Mediterranean. Thus the center of the Iceland LOW will be "called" in the direction of the region of the northerly winds. It is further remarked that this effect must be well marked at a number of stations, because a single station's observation may be influenced by the topographical character of the locality or the direction may be in error through inaccuracy of telegraphic transmission.

These rules are the result of study of 263 weather maps from the Bureau Central Météorológique for the LOWS and 246 for the HIGHS. The coefficients of certainty for each have been determined by months and by wind directions showing that, in the case of LOWS, the rule works more reliably in summer than in winter, the coefficients being 0.75 and 0.61, respectively. In the case of HIGHS, the coefficients are 0.74 and 0.58, respectively. With respect to wind directions, it appears that in both cases the northeast wind is the most likely to give the effect of "calling."

Three examples of the mutual action of HIGHS and LOWS are presented showing the use of the two rules. The first states that a depression tends to move about an area of high pressure in a clockwise manner. The winds of the northern part of a HIGH situated east of a LOW will tend to "call" the LOW; similarly, the winds in the southern part of a LOW tend to "call" the HIGH. The second asserts that in the case where a ridge of higher pressure separates two low centers, the winds flowing from the high-pressure ridge will constitute a call for winds from each of the low centers, thereby causing the union of the two centers and consequent increase in intensity of low pressure at the place of high pressure. The third case is that in which two high-pressure areas are separated by a valley of low pressure, and, in a manner similar to that above, the valley of low pressure will become the center of high pressure as the two HIGHS combine.—*C. L. M.*

A NOTE ON THE POSSIBILITY OF LONG-RANGE WEATHER FORECASTS.

By J. R. SUTTON.

[Abstracted from Transactions of the Royal Society of South Africa, Cape Town, vol. 8, pt. 1, pp. 17-19, 1919.]

Long-range weather forecasts may be divided into three classes, first, the random guesses of so-called weather prophets; second, forecasts based on cycles; and third, forecasts based on recognized physical or statistical principles. The last, though limited in scope and less ambitious than the other two, is the only one upon which any reliance can be placed. For South Africa examples of such physical relationships are "Winter droughts at Durban have invariably been followed by summer droughts in Mauritius" (easterly drift of barometric depressions across the Indian Ocean); and the relationship between Antarctic temperatures during August and September and those of Kimberley during the following October to December (Antarctic ice moves east-northeast in the current that washes the west coast of South Africa.)

In the present paper the author has sought to find a physical relation between the rainfall of the latter half of May and the temperature of June. He finds that when the second half of May is wet, June days tend to be cooler and nights warmer than when the latter half of May is dry. Heavier rains toward the end of May mean fewer cold June nights, and it happens that the coldest June nights come near the end of the month when there has been much rainfall in late May.

The physical basis of this relationship is quite obvious, for dry ground will cool faster by radiation than wet ground will by evaporation and radiation combined. Similarly, because of the greater specific heat of wet ground, June days are cooler after a wet May.—*C. L. M.*

THE INFLUENCE OF SNOW ON THE DEVELOPMENT OF VEGETATION IN SPRING.

By M. PEYRIGUEY JACQUES, in La Nature, April 17, 1920.

[Discussed by Katharine Davis.]

"Snow in February is worth as much as a fertilizer," is an old French peasant proverb. That there is some scientific basis for the belief is indicated by M. Peyriguey Jacques, assistant agricultural meteorologist, Montpellier, France, writing in La Nature, April 17, 1920.

He shows that from two standpoints a snow cover is valuable; (1) as a thermal blanket protecting soil and vegetation against freezes, and (2) for the supply of nitrogen compounds which is furnished to soil and plants by the melting snow.

(1) Investigating the problem of the effectiveness of protection by snow cover, M. Jacques made temperature records at Mont-Aigoual, Cevennes, southern France, with dry thermometers at depths of 0.1 m. and 0.2 m., respectively, in the snow and also at a height of 0.2 m. above the surface of the snow. The observations covered a period of 187 days during the winter and spring of 1916, when for 172 consecutive days the ground was snow covered. The accompanying table shows by decades the monthly mean temperatures of the snow and of the air during the months of February to April, inclusive, the May data not being given because the snow was constantly melting and its temperature remained at 0° C.

AT 0.2 M. ABOVE THE SNOW.

Periods.	February.	March.	April.
First decade	−4.6	−5.0	5.0
Second decade	−1.3	1.4	−0.4
Third decade	−2.8	1.3	7.0
Daily means	−2.9	−0.8	3.9

AT 0.1 M. IN THE SNOW.

First decade	−2.2	−4.1	0.0
Second decade	−1.1	−1.2	−0.5
Third decade	−2.3	−0.6	−0.1
Daily means	−1.8	−2.0	−0.2

AT 0.2 M. IN THE SNOW.

First decade	−2.2	−4.0	0.0
Second decade	−1.3	−1.2	−0.5
Third decade	−2.1	−0.4	−0.2
Daily means	−1.8	−1.8	−0.2

The table shows that there is no variation of the mean temperature of the thermal blanket at a depth of 0.2 m. during the months of February and March; that at 0.1 m. it is 0.2°, and that at 0.2 m. above the snow it is 2.1°. In April there is no variation during the first and third decades, and it is almost constant during the second decade. The temperature of the air, on the other hand, was decidedly variable during all of these periods.

Diagrams are included in the paper which show more graphically than can be done in tabular form that the air temperatures are much more variable than those of the snow, the range of these temperatures being as follows:

In the snow:		Above the snow:	
February	5.1°	February	11.5°
March	7.4°	March	10.4°
April	0.3°	April	21.8°

The figures show at a glance the efficiency of the thermal blanket afforded by the snow for the preservation of vegetation against freezing.

(2) To evaluate the quantities of nitric acid and of ammonia furnished to soil and vegetation by melting snow and rain, he uses figures obtained at the observatory at Mont-Souris, which agree with the data obtained at Mont-Aigoual, but which cover longer periods. He comments on the fact that snow contains nitric acid and ammonia in greater degree than rain does and also that soil and vegetation derive more benefit from these elements contained in snow as a greater amount is absorbed during the process of melting.

At the observatory of Mont-Souris it was found that the average quantity of nitric acid supplied by snow and rain during the years 1880 to 1894 was 400 milligrams per square meter per year, or 4 kilograms per hectare.

For the 20-year period from 1876 to 1895 the mean quantity of ammonia supplied by snow and rain was 1.086 grams per square meter per year, or 10.860 kilograms of ammonia per hectare. and, therefore, the soil at Mont-Souris was enriched, from an average depth of 551 mm. of melting snow and of rain per year, by a total of these nitrogen coupounds amounting to 14.860 kilograms per hectare.

Applying these figures, he finds that at Mont-Aigoual during a period of six months, December to May, inclusive, and for a depth of water of 1,621.7 mm., the soil was enriched by—

$$\frac{14.860 \times 1621.7}{551} = 43.736 \text{ kg.}$$

of nitrogen compounds per hectare, whose effects on the development of vegetation are therefore comparable to those of an average application of animal fertilizer.

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SPECIAL OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS.

By HERBERT H. KIMBALL, professor of meteorology.

[Dated: Solar Radiation Investigations Section, Washington, May 28, 1920.]

INSTRUMENTS AND EXPOSURES.

In the REVIEWS for August, 1914, **42**:474, and November, 1919, **47**:769, will be found illustrations and descriptions of the Callendar and the Marvin pyrheliometers, respectively. The former is employed by the Weather Bureau to obtain a continuous record of the total radiation received on a horizontal surface directly from the sun and diffusely from the sky. With the latter measurements are made of the intensity of direct solar radiation upon a surface normal to the incident solar rays whenever the sky about the sun is free from clouds. Both types are installed at Washington, D. C., Madison, Wis., and Lincoln, Nebr., and a Marvin pyrheliometer is installed at Santa Fe, N. Mex.

In the REVIEW for January, 1916, **44**:2, will be found a description of the exposures of the Marvin pyrheliometers at the above stations, which still apply, except for the modification in the exposure at Santa Fe noted in the REVIEW for January, 1917, **45**:2. Descriptions of the exposures of the Callendar pryheliometers at the different stations will be found in the REVIEW for January and April, 1916, **44**:4, 179 and 180, which still apply, except for the modification in the exposure at Madison, noted in the REVIEW for January, 1917, **45**:2.

Descriptions of the methods of obtaining and reducing radiation measurements will be found in the REVIEW for January and April, 1916, **44**:2, 4, 179, and 180, and for November, 1919, **47**:769. The Leeds and Northrup register used at Washington in connection with the Callendar pyrheliometer until September 27, 1919, was on that date replaced by a Callendar register. The determination of a new factor was necessary to reduce the records made by this register to heat units.

In the REVIEW for January, 1916, **44**:3, is given a description of the exposure of the Pickering polarimeter employed at Washington for measuring skylight polarization, and also an account of the manner in which the measurement is made. The exposure of a similar instrument in use at Madison is described in the REVIEW for January, 1917, **45**:2.

TABULATED DATA.

As explained in the REVIEW for January, 1916, **44**:2, measurements are made with the Marvin pyrheliometer when the sun has such zenith distances that the air mass is some multiple of 0.5, included between 1.0 and 5.5. Air mass 1.0, corresponding to zenithal sun, is never reached at any Weather Bureau station. On June 21, however, air masses of 1.03, 1.04, 1.05, and 1.06 are obtained at noon at Santa Fe, Washington, Lincoln, and Madison, respectively; while at noon on December 21 the corresponding air masses are 1.95, 2.15, 2.30, and 2.50.

In order that the data may be presented as compactly as possible, measurements are published only for air masses that are a multiple of 1.0. In addition, however, an extrapolation is made to obtain a value for zenithal sun, or air mass 1.0, whenever the character of the measurements will permit. If the extrapolation is for less than 0.25 air mass, the result is considered a measured value.

The following table gives the air mass corresponding to the noon position of the sun for each station on the 16th of each month, and indicate the amount of extrapolation necessary to obtain a radiation intensity value for air mass 1.

Date.	Washington, D. C.	Madison, Wis.	Lincoln, Nebr.	Santa Fe, N. Mex.
Jan. 16	1.99	2.27	2.10	1.81
Feb. 16	1.59	1.76	1.66	1.49
Mar. 16	1.31	1.41	1.36	1.26
Apr. 16	1.14	1.19	1.16	1.11
May 16	1.06	1.09	1.08	1.05
June 16	1.04	1.06	1.05	1.03
July 16	1.05	1.08	1.06	1.04
Aug. 16	1.10	1.14	1.12	1.08
Sept. 16	1.24	1.31	1.27	1.19
Oct. 16	1.49	1.67	1.55	1.40
Nov. 16	1.87	2.12	1.97	1.72
Dec. 16	2.14	2.49	2.29	1.94

Table 1 gives the measured intensities, and the extrapolated values for air mass 1.0, obtained during the months January to April, 1920, at the four stations equipped with Marvin pyrheliometers. When any monthly mean is based upon less than three measurements it is inclosed in parentheses. The "Departures" are the difference between the means for the current month and the means of all the corresponding measurements obtained at the station since the beginning of observations—June, 1905, Washington; July, 1910, Madison; July, 1915, Lincoln; and October, 1912, Santa Fe. Values obtained by extrapolation for more than 0.25 air mass are not included in this latter mean. The values of e, the surface vapor pressure, are obtained from psychrometer readings made at the respective stations at 8 a. m., 75th meridian time, and noon, local mean solar time.

The departures in Table 1 indicate that in January radiation intensities were slightly above the average at Washington and below the average at the other three stations; in February they were slightly above the average at Santa Fe, and below at the other stations; in March, above the average at Washington and Santa Fe, below at Madison and Lincoln; in April, below the average at Lincoln, above at Washington and Madison. No measurements were obtained at Santa Fe during April on account of a defect in the measuring apparatus.

TABLE 1.—*Solar radiation intensities during January, 1920.*

[Gram-calories per minute per square centimeter of normal surface.]

WASHINGTON, D. C.

Date.	Sun's zenith distance.									
	8 a.m.	77.8°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	77.8°	Noon
	75th meridian time.	Air mass.									Local mean solar time.
		A. m.					P. m.				
	e.	.0	4.0	3.0	2.0	1.0*	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Jan. 2	0.86	.....	1.04	.....	.....	.....	.....	.....	.....	.....	0.96
3	0.71	0.80	0.91	1.03	.....	.....	.....	.....	.....	.....	0.66
5	0.96	.....	1.03	1.18	1.36	1.57	.....	1.22	1.08	0.95	1.07
10	2.62	.....	0.61	0.77	.....	1.23	.....	.....	.....	.....	3.81
12	2.36	0.63	0.71	0.88	1.07	1.69	1.32	1.03	.....	.....	1.78
14	1.24	0.82	0.94	.....	1.25	1.56	.....	0.95	0.73	.....	1.19
28	5.36	.....	.....	.....	.....	.....	.....	0.91	0.80	0.69	4.17
29	1.60	.....	.....	.....	1.21	.....	.....	0.90	.....	.....	1.96
30	2.87	.....	.....	0.99	1.14	.....	1.03	0.93	.....	.....	3.63
31	1.60	0.95	1.06	1.18	1.32	1.54	1.33	1.17	0.98	0.90	0.81
Means	.....	**0.80**	**0.90**	**1.00**	**1.22**	**1.52**	**1.23**	**1.02**	**0.90**	**0.85**	.....
Departures	.....	**+0.05**	**+0.02**	**−0.01**	**±0.00**	.....	**± .00**	**−0.02**	**+0.02**	**+0.07**	.....

*Exptrapolation.

TABLE 1.—*Solar radiation intensities during January, 1920*—Continued.

MADISON, WIS.

Date.	Sun's zenith distance. 8 a.m.	77.8°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	77.8°	Noon
	75th meridian time.	Air mass. A. m.					P. m.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	1.0*	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Jan. 2	0.43							1.28			0.48
13	1.96		1.08	1.27		1.61		1.34	1.22		1.24
28	0.64	0.80	0.94	1.11	1.29	1.53					0.91
Means		(0.80)	(1.01)	(1.19)	(1.29)	(1.53)		(1.31)	(1.22)		
Departures		−0.14	−0.07	−0.06	−0.06			+0.07	+0.08		

LINCOLN, NEBR.

Jan. 2	1.78	1.05	1.11	1.24							1.32
9	1.19			1.10		1.44		1.14	0.98		2.49
12	3.30					1.54		1.05	0.94		3.99
14	3.45	0.74	0.88								4.37
15	3.99		0.89	1.17							4.37
17	2.16		1.09	1.24		1.58					2.36
21	1.19		0.99	1.16		1.54		1.18	1.04	0.91	2.06
27	1.37				1.19		1.19				1.24
29	2.62				1.25	1.49	1.28	1.10	0.94		6.02
Means		(0.90)	0.99	1.18	(1.22)	1.52	(1.24)	1.12	0.98	(0.91)	
Departures		−0.05	−0.06	±0.00	−0.14		−0.01	−0.09	−0.10	−0.09	

SANTA FE, N. MEX.

Jan. 9	0.86			1.30	1.47	1.67	1.40		1.14		1.52
12	1.88							1.23			2.62
14	2.26				1.38						2.87
24	3.00		1.18	1.34				1.33			3.30
27	2.87								1.23		3.45
28	3.15				1.46	1.58		1.34	1.23		3.63
29	2.16			1.34	1.52	1.72	1.49	1.41	1.23		2.74
30	3.15			1.41	1.50		1.50	1.38	1.27		2.62
Means			(1.18)	1.35	1.47	1.65	1.46	1.34	1.22		
Departures			−0.09	−0.03	−0.03		−0.01	±0.00	+0.01		

Solar radiation intensities during February, 1920.

WASHINGTON, D. C.

Feb. 13	5.16						1.01				4.75
14	3.99						1.01				4.75
16	0.79		0.66								0.79
17	1.52						1.24	1.03			1.96
19	2.74		0.77	1.05	1.28	1.56	1.26	1.01	0.78		1.52
20	1.68			0.82	1.04						1.88
25	1.78		0.77	0.92	1.10	1.31					1.78
26	1.52			0.72							1.37
Means			0.73	0.88	1.14	(1.44)	1.13	(1.02)	(0.78)		
Departures			−0.11	−0.13	−0.07		−0.09	+0.01	−0.07		

MADISON, WIS.

Feb. 19	0.71				1.15						0.51
25	1.37				1.29						1.32
26	0.58			1.21	1.38	1.62	1.38				0.86
Means				(1.21)	1.27	(1.62)	(1.38)				
Departures				−0.03	−0.11		−0.02				

LINCOLN, NEBR.

Feb. 7	3.81						1.20	0.94	0.84	0.82	5.16
9	3.81						1.32				3.30
10	3.30				1.33						3.63
14	0.91			1.26				1.27	1.12	0.97	0.96
16	1.78					1.46	1.24	1.05	0.94	0.80	3.00
17	3.00			1.25	1.37						3.45
19	4.57						1.23	1.00	0.88	0.77	4.57
26	1.02		1.17	1.26	1.44	1.64	1.35				1.45
27	2.36									0.89	3.00
Means			(1.17)	1.26	1.38	(1.55)	1.27	1.08	0.93	0.85	
Departures			+0.08	+0.02	−0.04		−0.08	−0.11	−0.10	−0.04	

*Extrapolated.

TABLE 1.—*Solar radiation intensities during February, 1920*—Continued.

SANTA FE, N. MEX.

Date.	Sun's zenith distance. 8 a.m.	77.8°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	77.8°	Noon.
	75th meridian time.	Air mass. A. m.					P. m.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	1.0*	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Feb. 14	2.26					1.64		1.29	1.18	1.01	2.87
15	1.96			1.40	1.54						2.26
16	3.00					1.68	1.44				3.99
17	2.87				1.47	1.57					3.81
18	2.49				1.52	1.62					2.62
26	2.26			1.34	1.51			1.37	1.23	1.12	2.36
27	2.87					1.72					2.87
Means				(1.37)	1.51	1.65	(1.44)	(1.33)	(1.20)	(1.06)	
Departures				+0.06	+0.04		+0.04	+0.03	+0.02	−0.01	

Solar radiation intensities during March, 1920.

WASHINGTON, D. C.

Mar. 1	1.45			1.04	1.28	1.56	1.23	0.97			2.16
2	3.15			0.53	0.81		0.94	0.64	0.46		2.74
3	3.30			0.74		1.34	1.06				4.37
6	1.12			1.13	1.36						1.24
8	1.24			1.10	1.26	1.47					1.68
10	3.45				1.05	1.39	1.07				4.17
14	2.06					1.56	1.36	1.15	1.04	0.94	1.32
18	3.30				1.17	1.44					2.49
22	4.57		0.91	1.04	1.19	1.39	1.07	0.87	0.74		3.30
23	5.16		0.82	0.98	1.16	1.43					3.99
24	6.02				1.25	1.36	1.12				5.79
27	4.75			1.07	1.23	1.36	1.18	0.95			3.81
30	3.81		0.96	1.09	1.24	1.36					3.63
Means			0.90	0.97	1.18	1.42	1.13	0.92	0.75	(0.94)	
Departures			+0.09	+0.02	+0.01		±0.00	−0.02	−0.06	−0.23	

MADISON, WIS.

Mar. 1	1.96		1.09	1.22	1.35	1.48	1.28				1.12
5	0.53			1.27	1.42	1.60					0.48
6	0.36			1.15							0.46
13	1.45					1.58	1.34	1.14			1.88
17	1.68			1.18	1.33	1.49	1.25	1.02			2.49
20	3.15				1.22		1.23				3.63
27	3.99						1.04				5.79
30	4.95				1.21						4.75
Means			(1.09)	1.20	1.31	1.54	1.23	(1.08)			
Departures			+0.03	±0.00	−0.02		−0.11	−0.10			

LINCOLN, NEBR.

Mar. 2	3.63			1.02	1.25						4.95
4	0.91			1.23	1.34	1.46					1.37
8	2.49						1.26	1.07	0.88	0.77	2.74
9	3.45		0.85	1.03	1.19	1.36					3.99
12	2.36						1.35	1.07	0.99		3.30
16	2.36	0.89	1.07	1.17	1.34			1.05	0.94	0.82	3.00
20	3.81	0.86	0.96			1.49	1.28	1.10	0.99	0.83	3.99
21	3.45		0.86	1.01	1.18	1.39	1.24				3.99
22	3.45		0.95	1.06		1.32					3.81
26	4.17			1.00	1.23	1.51	1.24	1.04	0.88	0.73	3.63
27	6.27		0.90	1.05	1.27						4.95
29	3.81				1.34						3.15
30	3.81			0.92	1.23	1.46	1.29	1.11	0.94	0.84	2.62
31	5.36		0.89	1.05	1.24	1.46					6.27
Means		(0.88)	0.93	1.05	1.26	1.43	1.28	1.07	0.94	0.80	
Departures		−0.04	+0.01	−0.04	−0.04		+0.01	−0.02	−0.01	−0.01	

SANTA FE, N. MEX.

Mar. 8	2.36			1.26					1.01	0.90	2.16
9	2.36				1.22						3.30
12	2.06				1.46						2.62
15	2.62					1.60	1.42	1.25	1.13		2.16
18	1.88			1.33		1.68		1.27	1.18	1.10	2.49
19	2.16			1.37	1.48	1.64	1.46	1.33	1.20	1.11	2.62
20	1.96		1.24	1.30	1.48		1.39	1.27	1.18	1.07	1.78
Means			(1.24)	1.32	1.41	1.64	1.42	1.28	1.14	1.04	
Departures			+0.04	±0.00	−0.04		+0.03	+0.03	+0.04	+0.01	

*Extrapolated.

TABLE 1.—*Solar radiation intensities during April, 1920*—Continued.

WASHINGTON, D. C.

Date.	Sun's zenith distance. 8 a.m.	77.8°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	77.8°	Noon
	75th meridian time.	Air mass. A. m.					P. m.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	1.0*	2.0	3.0	4.0	5.0	e.
	mm.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Apr. 3	3.30	.....	1.02	1.15	1.30	1.49	.....	.....	.....	.....	2.74
6	1.78	.....	.....	.....	1.20	.....	.....	.....	.....	.....	1.96
10	2.26	.....	.....	.....	.....	1.43	.....	.....	.....	.....	2.49
13	5.16	.....	.....	.....	1.07	.....	.....	.....	.....	.....	3.15
21	9.47	.....	.....	.....	.....	1.44	1.29	1.03	.....	.....	10.59
22	7.29	.....	0.76	0.91	.....	.....	.....	.....	.....	.....	5.79
29	6.76	.....	.....	0.99	1.18	1.41	1.17	.....	.....	.....	4.17
Means	.....	.....	**(0.89)**	**1.02**	**1.19**	**1.44**	**(1.23)**	**(1.03)**	.....	.....	.....
Departures	.....	.....	**+0.14**	**+0.15**	**+0.13**	**+0.06**	**+0.14**	**+0.11**	.....	.....	.....

MADISON, WIS.

Apr. 3	1.24	.....	.....	.....	1.29	.....	.....	.....	.....	.....	2.26
8	1.78	.....	.....	.....	1.22	1.42	.....	.....	.....	.....	2.16
9	2.62	.....	.....	.....	1.25	.....	.....	.....	.....	.....	2.87
13	1.96	.....	.....	.....	1.31	1.50	.....	.....	.....	.....	3.15
14	2.49	.....	.....	.....	1.24	.....	.....	.....	.....	.....	2.49
17	3.99	.....	.....	.....	1.15	.....	.....	.....	.....	.....	4.37
24	4.17	.....	.....	.....	.....	1.45	0.98	.....	.....	.....	5.16
Means	.....	.....	.....	.....	**1.24**	**1.46**	**(0.98)**	.....	.....	.....	.....
Departures	.....	.....	.....	.....	**±0.00**	**+0.06**	**−0.27**	.....	.....	.....	.....

LINCOLN, NEBR.

Apr. 2	.....	.....	1.09	1.23	1.40	.....	.....	.....	.....	.....	.....
9	.....	.....	0.61	0.79	1.01	.....	.....	.....	.....	.....	.....
13	.....	.....	0.76	0.88	1.08	.....	.....	.....	.....	.....	.....
20	.....	.....	0.81	0.93	1.14	1.40	.....	.....	.....	.....	.....
21	.....	.....	.....	0.93	1.15	1.44	1.06	0.84	0.60	0.46	.....
27	.....	.....	0.95	1.08	1.30	1.59	.....	.....	.....	.....	.....
28	.....	.....	.....	0.95	1.24	1.50	.....	.....	.....	.....	.....
Means	.....	.....	**0.84**	**0.97**	**1.19**	**1.49**	**(1.06)**	**(0.84)**	**(0.60)**	**(0.46)**	.....
Departures	.....	.....	**+0.01**	**−0.04**	**−0.04**	**±0.00**	**−0.10**	**−0.14**	**−0.23**	**−0.25**	.....

* Extrapolated.

Table 2 gives the average daily solar and sky radiation received on a horizontal surface for each weekly period from January 1 to April 29, 1920, inclusive. The period from February 26 to March 4 in 1920 contains 8 days. The weekly means of the departures of the daily values from normal values, and also the excess or deficiency of radiation since the first of the year, are also given. All three stations show a marked deficiency of radiation from about January 15 to February 25, and an excess during the first half of April.

During the months January to April, 1920, fewer skylight polarization measurements than usual were obtained at Washington and Madison, as the ground was frequently entirely or partly covered with snow. The measurements show about the average percentage of polarized light.

TABLE 2.

Week beginning—	Average daily radiation. Washington.	Madison.	Lincoln.	Average daily departure for the week. Washington.	Madison.	Lincoln.	Excess or deficiency since first of year. Washington.	Madison.	Lincoln.
	cal.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Jan. 1	189	156	134	27	11	− 54	188	80	− 375
8	156	184	209	− 11	29	7	109	281	− 326
15	135	154	219	− 41	−18	0	− 176	158	− 323
22	113	179	200	− 77	−13	− 35	− 717	66	− 571
29	189	176	107	− 17	−32	−145	− 839	− 160	−1,584
Feb. 5	197	156	235	− 30	−70	− 34	−1,051	− 648	−1,820
12	276	249	334	26	2	44	− 871	− 631	−1,513
19	187	251	153	− 82	−15	−161	−1,446	− 735	−2,638
26	355	307	387	66	15	44	− 922	− 618	−2,287
Mar. 5	340	372	419	29	52	44	− 720	− 256	−1,976
12	314	341	427	− 20	1	26	− 860	− 249	−1,794
19	410	276	396	61	−82	− 20	− 433	− 820	−1,933
26	363	342	450	− 4	−30	31	− 460	−1,028	−1,715
Apr. 2	397	468	488	10	82	73	− 393	− 455	−1,204
9	594	422	443	189	25	40	932	− 281	− 924
16	382	336	248	− 45	−78	−161	619	− 829	−2,053
23	436	343	391	13	−93	− 40	526	−1,476	−2,336

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

By C. G. ABBOT, Assistant Secretary.

[Smithsonian Institution, Washington, May 19, 1920.]

In continuation of preceding publications, I give in the following table the results obtained at Calama, Chile, in March, 1920, for the solar constant of radiation. The reader is referred to this REVIEW for February (pp. 85–87), August (pp. 580–582), and September (pp. 658–659), 1919, for statements of the arrangement and meaning of the table.

During the month of March only three days were lost to observation. This is very fortunate, for the month has been extremely interesting, owing to the remarkable solar phenomena centering about March 22. As shown in the following table of five-day mean values of the solar constant of radiation for the period beginning June 1, 1919, the broad features of the march of solar radiation values have been unusually interesting. In each month I have indicated the successive five-day periods by the capital letters A, B, C, D, E, and F. The last pentad includes all the days from the 26th to the end of the month. The values given are the number of thousandths of a calorie by which the solar radiation of a given time interval exceeds 1.900. Thus, for the first period of June the mean value is 1.946.

Approximate five-day mean solar-radiation observations.

	A.	B.	C.	D.	E.	F.[1]
1919.						
June	46	84	37	39	71	53
July	36	54	47	63	57	31
August	53	54	38	36	51	45
September	28	33	30	42	31	30
October	[2] 18	[3] 57	49	46	59	62
November	60	51	60	43	47	54
December	55	48	54	60	67	81
1920.						
January	69	102(?)	74	78	81	70
February	.....	87	60	78	77	68
March	77	65	70	50	10	59

[1] Means for all the days from the 26th to the end of the month.
[2] Means for the 2d and 7th.
[3] Mean for the 8th, 9th, and 10th.

Up until the 7th of October there was, on the whole, a steady decline which had at last brought the observed values below the value 1.933 calories per square centimeter per minute representing the mean of the observations from 1903 to 1912, published in Volume III of the Annals of the Astrophysical Observatory. The concluding value of this series, taken October 7, is very strong since it depends upon a mean of four well-agreeing observations—three by the new method and one by the old. That value was 1.891. The value for the next following day, October 8, the mean of three well-agreeing observations by the new method, is 1.963. From this time until the middle of December, the values continued at the high average of 1.954. Then occurred a further rise to abnormally high averages; and for almost three months, from December 22 to March 17, the average value was about 1.976. There has not been so long-continued a period of high values during the time when the solar constant has been observed by the Smithsonian Institution, from 1905 until now.

Then occurred the remarkable, well-delineated large depression shown by the following values and having its minimum on March 23, only a few hours after the maximum activity of the sun, revealed by the great sun spots, aurorae, and the terrestrial magnetic disturbances of March 22 and 23. It is interesting to state in anticipa-

tion that with the recurrence of this disturbed solar region to a central position on the sun's disk on April 15 to 18 a similar though less deep depression of solar radiation values occurred.

Solar radiation observations of March, 1920.

Date	11–17[1]	18	19	20	21	22	23	24	26	27	28	29	30	31
Value	1.968	1.954	1.940	1.931	1.941	1.927	1.866	1.905	1.953	1.966	1.958	1.969	1.951	1.957

[1] Mean.

An interesting feature of the march of observations is the long series of values obtained on March 11 covering the entire available part of the day and including 2 solar constant values by the old method and 20 by the new. The results are given in the following table:

Observations of Mar. 11, 1920.

Time		7:16	7:36	8:03	8:55	9:20	9:50	10:20	10:50	11:20	11:50
Method	E_0	M_3	$M_{3.5}$	M_3	$M_{1.5}$	$M_{1.4}$	$M_{1.24}$	$M_{1.16}$	$M_{1.10}$	$M_{1.07}$	$M_{1.06}$
Value	1.961	1.985	1.997	1.976	1.981	1.961	1.948	1.956	1.952	1.949	1.957
Grade	E−	S	S	S	S	S	S	S	S	S	S

Time	12:20	12:50	1:20	1:50	2:20	2:50	3:05	3:54	4:22	4:40	
Method	$M_{1.06}$	$M_{1.08}$	$M_{1.12}$	$M_{1.19}$	$M_{1.29}$	$M_{1.48}$	$M_{1.5}$	M_3	$M_{2.5}$	M_3	E_0
Value	1.955	1.962	1.958	1.964	1.972	1.971	1.970	1.967	1.983	1.973	1.954
Grade	S	S	S	S	S	S	S	S	S	S	E−

Another similar series was taken on March 29, but the computations have not yet been completed. The observations of March 11 seem to follow a very smooth and definite course of variation, as if the intensity of sun rays were rather rapidly diminishing during the morning hours and more slowly recovering through the afternoon. As would be the case if this apparent change were real, the two values obtained by the old method are slightly below the values obtained by the new. It is, however, too early to suppose that all the sources of error are so minimized that this small change in one day is a really solar phenomenon. It may be possible that difference in the inclination of the pyrheliometer, or some other instrumental error, may have tended to produce this depression toward the noon hours. Further experiments are intended.

On the whole, the month of March has been far more cloudless than preceding months, and it is hoped that better weather conditions will now persist.

Date.	Solar constant.	Method.	Grade.	Transmission coefficient at 0.5 micron.	Humidity.			Remarks.
					ρ/ρ sc.	V. P.	Relative humidity.	
1920	*cal.*					*cm.*	%	
P. M.								
Mar. 1	1.980	$M_{1.25}$	S−	0.822	0.399	0.88	44	Cirri in south and west. Cirro-cumuli in north and east.
A. M.								
2	2.002	M_2	S	.824	.295	.73	49	Some very thin cirri low in east and some in west.
	9.997	$M_{1.5}$						
	2.000	W.M.						
3	1.968	M_3	S−	.814	.206	.86	73	Some cirri in distant east and north.
	1.984	M_2						
	1.981	$M_{1.5}$						
	1.980	W.M.						
P. M.								
5	1.949	$M_{1.26}$	S−	.835	.399	.86	46	Cumuli scattered over most of sky.
A. M.								
6	1.973	$M_{1.28}$	U+	.828	.407	.86	65	Considerable cumuli, especially in east.
7	1.971	$M_{1.14}$	S−	.837	.439	.95	70	Cumuli scattered about most of sky, especially in east.
8	1.956	$M_{1.20}$	S−	.831	.410	.84	59	Cumuli scattered about sky.
10	1.958	$M_{1.33}$	S	.840	.467	.63	46	Some distant cumuli in east and north.
	1.960	$M_{1.24}$						
	1.959	W.M.						
11	1.961	E_0	E−	.841	.331	.60	59	
	1.985	M_3						
	1.976	M_2						
	1.981	$M_{1.5}$						
	1.978	W.M.						
12	1.989	M_3	S−	.834	.351	.66	48	Cirri in west. Cumuli forming in east.
	1.964	$M_{1.5}$						
	1.981	W.M.						
13	1.963	M_3	S	.836	.292	.60	52	Streak of cirri low in east.
	1.960	M_2						
	1.955	$M_{1.5}$						
	1.959	W. M.						
14	1.932	E_0	VG	.846	.344	.49	46	Very distant cirri in northeast.
	1.985	M_3						
	1.968	M_2						
	1.956	$M_{1.5}$						
	1.962	W. M.						
15	1.986	M_3	S	.847	.378	.42	36	
	1.965	M_2						
	1.967	$M_{1.5}$						
	1.969	W. M.						
16	1.965	M_3	S	.841	.429	.56	43	Streaks of cirro-cumul in east and south.
	1.966	$M_{1.5}$						
	1.965	W. M.						
17	1.931	E_0	E−	.833	.307	.64	60	Trace of cirri in northeast.
	1.972	M_3						
	1.964	M_2						
	1.964	$M_{1.5}$						
	1.962	W. M.						
18	1.946	M_3	S	.834	.339	.66	52	
	9.955	M_2						
	1.961	$M_{1.5}$						
	1.954	W. M.						
19	1.936	$M_{1.29}$	S−	.832	.481	.67	42	Thin cirri in east. Sun possibly in very thin cirri during observations.
	1.944	$M_{1.23}$						
	1.940	W. M.						
20	1.932	$M_{1.28}$	S−	.836	.508	.74	46	Thin cirri in east and north.
	1.930	$M_{1.22}$						
	1.931	W.M.						
21	1.918	M_3	S−	.824	.275	.62	51	Cirri low in east spreading to north. Cumuli forming in east.
	1.952	M_2						
	1.944	$M_{1.5}$						
	1.941	W. M.						
22	1.925	$M_{1.16}$	S−	.819	.425	.88	56	Scattered cirro-cumuli in east and south. Cumuli in north.
	1.930	$M_{1.13}$						
	1.927	W. M.						
23	1.850	M_3	U	.820	.359	.83	65	Cirro-cumuli low in east.
	1.881	$M_{1.5}$						
	1.866	W. M.						
24	1.906	M_3	S−	.825	.340	.71	51	Few small cumuli in north and south. Small cirro-cumuli in east.
	1.904	$M_{1.5}$						
	1.905	W. M.						
26	1.955	$M_{1.5}$	S	.829	.354	.76	54	Cirri in east. Cumuli forming in northwest and south.
	1.951	$M_{1.99}$						
	1.953	W. M.						
27	1.967	E_0	E−	.855	.492	.35	34	
	1.978	M_3						
	1.964	M_2						
	1.956	$M_{1.5}$						
	1.966	W. M.						
28	1.945	M_3	S−	.866	.535	.30	25	
	1.970	M_2						
	1.960	$M_{1.5}$						
	1.958	W. M.						
29	1.953	E_0	E−	.854	.426	.31	27	
	1.976	M_3						
	1.975	M_2						
	1.966	$M_{1.5}$						
	1.969	W. M.						
30	1.924	E_0	VG	.851	.451	.37	33	
	1.955	M_3						
	1.952	M_2						
	1.940	$M_{1.5}$						
	1.951	W. M.						
31	1.959	E_0	VG−	.845	.425	.31	29	Cirro-cumuli in northeast and little in west.
	1.965	M_2						
	1.937	$M_{1.5}$						
	1.957	W. M.						

WEATHER OF THE MONTH.

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH PACIFIC OCEAN.

By F. G. TINGLEY.

Atmospheric conditions over the North Pacific Ocean during April were marked by an almost complete absence of any strong air movement. So far as reports at hand show, no storms of importance occurred. There were but few occasions during the month when the wind reached the force of a gale. One of these was from the 8th to the 12th, when a fresh to whole gale was experienced over a limited region in the Gulf of Alaska; another from the 15th to the 20th, when moderate to strong northwesterly gales prevailed along the middle North American coast, extending as far south as the 20th parallel.

On the Asiatic side cyclonic disturbances, apparently of only moderate intensity, occurred during the 1st, 2d, and 3d, the 19th and 20th, and the 29th and 30th. Shipping within the regions affected received wireless warnings of these depressions from Asiatic meteorological services.

Considerable fog prevailed along the northern steamer route. The observer on the U. S. Army transport, *Mount Vernon*, from Vladivostok for San Francisco, commenting on the weather experienced during the voyage, stated that a report of conditions "could be summed up as follows: Continuous fog, dense most of the time, with intervals clear for short periods, but accompanied by light rain squalls."

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month was considerably below the normal at land stations along the American and northern European coasts, and in the Azores, while it was slightly above in the West Indies and Bermuda.

As far as could be judged from reports received, the number of days on which gales were observed over the steamer lanes was not far from the normal, while they were somewhat more frequent than usual in the vicinity of Cape Hatteras.

Fog was apparently less prevalent than usual during the month, especially on the Banks of Newfoundland, where the maximum amount usually occurs; off Nantucket Shoals it was reported on five days, which is not far from the normal.

On the 1st and 2d moderate to strong gales, accompanied by hail and snow, prevailed over a limited region between the 35th and 43d parallels and the 45th and 60th meridians. On the 3d and 4th the weather conditions were comparatively moderate, although on the 4th, a few vessels in the western section of the steamer lanes reported northwesterly gales.

On the 5th, as shown on Chart IX, a LOW was central near latitude 45°, longitude 37°, with moderate to strong northwest gales in the southwesterly quadrants, the storm area extending as far south as the 32d parallel. On the same day there was a second disturbance central near Norfolk, while southerly winds of gale force were reported from a limited area between the 70th meridian and the Carolina coast.

The storm log of the Italian S. S. *Argentina* is as follows: "Gale began on April 4. Lowest barometer, 29.03 inches at 10 p. m. on the 4th; position, 40° 36′ N., 43° 59′ W. End of gale on the 5th. Highest force of wind, 11; shifts of wind, SE.-S.-NW."

The observer on the American S. S. *Munra* reports as follows: "Gale began on the 5th. Lowest barometer, 29.48 inches at 4 p. m. on the 5th; position, 32° 30′ N., 73° 55′ W. End of gale on the 7th. Highest force of wind, 11; shifts of wind, SW.-WNW. At 4 p. m. on the 5th sea increasing; at 10 p. m. ship hove to, very heavy sea running." On the 8th and 9th moderate to strong westerly gales were prevalent over the area between the 35th and 42d parallels and the 50th and 60th meridians, and on the former date easterly winds of about 40 miles an hour were reported from the eastern section of the steamer lanes.

Charts XI to XV, covering the period from April 10 to 14, inclusive, show the progress of an exceptionally well-developed and severe disturbance. That on the 10th was central near latitude 48°, longitude 27°; it drifted slowly eastward and on the 13th the center was near the south coast of Ireland. This storm reached its greatest intensity on the 12th, as shown by the following extracts from storm reports. British S. S. *Lepanto:* "Gale began on the 11th. Lowest barometer, 28.31 inches; position, 49° 43′ N., 9° 45′ W. End of gale on the 13th. Highest force, 11; shifts of wind, SSE.-S.-SW.-W.-WNW.-W. The observer on the American S. S. *New York City* reports that on the 12th the barometer reading at 1 a. m. was 28.10 inches, wind SE., force 6, and rain. The barometer fell slowly, reaching its lowest reading of 27.98 inches between 3 and 4 a. m.; at the latter hour the wind was from the west, force 4, accompanied by heavy confused sea. At 10 a. m. the barometer had risen to 28.13 inches, and the wind had increased to gale force. The position of the vessel at Greenwich mean noon was given as 50° 56′ N., 14° 35′ W."

From the 12th to the 14th, as shown on Charts XIII to XV, inclusive, there was a second disturbance of less intensity than the first, that covered a limited area in midocean. The storm log from the American steamship *West Isleta* is as follows: "Gale began on the 13th. Lowest barometer, 29.06 inches, at noon on the 13th; position, 44° 53′ N., 36° 45′ W. End of gale on the 15th. Highest force of wind, 10; shifts of wind, SW.-N.-NW.-N.-NW."

On the 15th a few reports were received denoting westerly to southwesterly gales between the 10th meridian and the French coast, and the observer at Horta, Azores, reported a northwest gale of over 50 miles, although vessels in the region north of the 40th parallel and between the 15th and 35th meridians experienced moderate weather. From the 16th to 18th a few reports were received from vessels in widely scattered sections of the ocean that had encountered moderate gales, though these were an exception to the general rule.

On the 19th the British steamship *Turcoman*, while about 200 miles west of the south coast of Ireland, encountered a strong westerly gale. The storm log is as follows: "Gale began at 4 a. m. on the 19th. Lowest barometer, 29.22 inches, at 8 a. m. on the 19th; position, 50° 52′ N.,

14° 30′ W. End of gale at 6 p. m. on the 20th. Highest force of wind, 10; shifts of wind, 2 points." This gale must have been very local in character, as other vessels in the vicinity experienced moderate winds. By the 20th this disturbance had increased considerably in extent and intensity, as strong northwesterly gales prevailed between the 15th meridian and the French coast. On the 23d the American steamship *Macomet* ran into a nothwest gale about 300 miles east of Bermuda. The storm log is as follows: "Gale began on the 23d. Lowest barometer, 29.74 inches, at 6 a. m. on the 23d; position, 33° 40′ N., 58° 03′ W. End of gale at 6 p. m. on the 23d. Highest force of wind, 9; shifts of wind, W.-WNW.-N." As can be seen from the report, this storm was of short duration, and it also covered a limited area; one vessel near latitude 38°, longitude 61°, experienced a northwest gale of about 50 miles an hour, while a number of other ships in the vicinity encountered only light to moderate winds.

On the 24th the station at New York reported a northwest wind of 52 miles an hour, with a barometer reading of 29.64 inches. This disturbance was of limited extent, as no vessel reports were received denoting heavy weather in that locality.

On the 26th a vessel near latitude 37°, longitude 58°, reported a westerly gale of over 50 miles an hour, while over the remainder of the ocean moderate weather prevailed.

The conditions during the rest of the month were comparatively featureless with slight pressure gradients and light winds, except that on the 30th the barometer reading at the Azores was unusually low, while in Iceland it was well above the normal. This reversal of the ordinary conditions was responsible for the easterly winds that prevailed over the intervening territory, although no high velocities were reported.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

British Isles.—From the first day, which was dull and rainy in London and many other parts of Great Britain, to the last, on which hailstorms were widespread, April was unsettled, showery, and inclement. * * *

General deficiency of sunshine kept the daytime temperature very low, so that at numerous stations the mean maximum temperature was below the normal. On the other hand, owing to the persistent cloudiness, the nights were unusually warm. * * *

The general rainfall, expressed as a percentage of the average was: England and Wales, 204; Scotland, 100; Ireland, 146. * * *

In London (Camden Square) the mean temperature was 49.3° F., or 1.2° F. above the average. The duration of rainfall, 73.1 hours, was the largest recorded in April since these observations were started in 1881. Evaporation 0.85 inch.[1]

Northwestern Europe.—Pressure was high over Iceland and a series of depressions, none of them of great intensity, passed slowly across the British Isles. The most severe occurred at the end of the month and caused gales in the Baltic on the 30th. The result was an unsettled month in western Europe, cold and snowy in Norway, rainy and not particularly mild farther south. * * *[1]

Switzerland.—Geneva, April 12.—A number of visitors and some scientists are witnessing a strange Alpine phenomenon at Grindelwald, where the famous Grindelwald glacier has been moving into the valley at the rate of 4 to 6 feet daily.

It has already destroyed a pine forest and crushed a stone bridge across the Black Lutschine into atoms. The ice river continues advancing across the water to the upward bank.

The rapid movement is due to the enormous amount of ice and snow on the higher portions of the glacier. The ordinary pace of a glacier is a few yards in 50 years.—*Herald, Elmira, N. Y., April 13, 1920.*

* * * On the 18th very heavy rain fell in Switzerland—91 mm. at Berne and 75 mm. in Lugano. * * *.[1]

Spitzbergen.—* * * 48 degrees of frost was recorded at Spitzbergen on the 13th, but on the 21st the temperature there rose suddenly to a maximum of 34° F.[1]

India.—On April 23 a violent cyclone passed over Manikganj, a small town in Bengal, killing 93 persons.[1]

Australia and New Zealand.—Unusually wet weather appears to have prevailed in New Zealand and in Northern and Eastern Australia.[1]

[1] The Meteorological Magazine, May, 1920, pp. 75 and 80.

[1] The Meteorological Magazine, May 1920, pp. 75 and 80.

DETAILS OF THE WEATHER OF THE MONTH IN THE UNITED STATES.

CYCLONES AND ANTICYCLONES.

By R. HANSON WEIGHTMAN, Meteorologist.

Cyclones.—The number of LOWS was much greater than the average. The Alberta LOWS, all of which made their appearance over the western portion of that region, gave birth to secondaries in most cases. In the west and central portions of the country, LOW tracks were south of the normal, while in the East the tendency was to the northward. The table below gives the number of LOWS by types.

LOWS.

	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf.	South Atlantic.	Central.	Total.
April, 1920	5.0	2.0	0.0	2.0	2.0	1.0	0.0	3.0	2.0	17.0
Average number 1892–1912	3.4	1.5	0.9	0.5	1.3	0.9	0.3	0.6	0.7	10.3

Anticyclones.—The number of HIGHS was also above the average, especially the Alberta type of which there were 7. High pressure centers persisted for considerable periods to the west of Hudson Bay and on the north Pacific coast. The distribution of HIGHS by types is indicated in the table hereunder.

HIGHS.

	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain region.	Hudson Bay.	Total.
April, 1920	1.0	2.0	7.0	2.0	0.0	12.0
Average number 1892–1912	1.6	1.6	3.1	1.0	0.6	7.9

THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and chief of division.

[Dated: Weather Bureau, Washington, D. C., June 2, 1920.]

PRESSURE AND WINDS.

The first few days of the month were marked by rapid and pronounced pressure variations, and storms with steep gradients and of wide extent covered the districts from the Mississippi River eastward. The first storm moved from the southern plains region to the upper Lakes by the morning of the 2d, at which time the sea-level pressure near the center of the storm was below 29 inches, and low pressure prevailed as well over most other districts. The second storm had developed considerable proportions by the morning of the 3d in the far Southwest, and during the 4th and 5th moved to the Atlantic coast districts, attaining wide proportions and causing unusually heavy falls of snow for April over its northern side, particularly from Kansas and Nebraska eastward to the Great Lakes, but without the usual extensively heavy rains to the south and east attending such storms. The pressure was markedly low over the Atlantic coast districts on the 5th; in fact, at many points the readings at some period of the day were the lowest ever observed, and the highest winds of the month prevailed as the storm passed northeastward over New England to the Canadian Maritime Provinces during that and the following day. The latter portion of the first decade was mostly free from decided barometric changes, but during the early part of the second a storm moved eastward over the middle portions of the country, and precipitation was widespread and fairly heavy over the more eastern districts. The latter part of the decade brought stormy conditions due to the passage of a low-pressure area from the far Northwest into the middle Rocky Mountains and plains regions. This storm was attended by unusually heavy snows in the mountains of Colorado and Wyoming and parts of adjoining States as well as over portions of the plains region to the eastward. The snowfall reached unusual depths in the mountains and ranged from 12 to 18 inches on the plains adjoining, greatly delaying traffic and causing much suffering to stock. The eastward progress of this storm was unusually slow, and rainy conditions resulting from general low pressure over the interior districts continued over the central valleys and to the eastward into the early part of the third decade. About the 25th low pressure again set in over the plains region and gradually overspread the Mississippi Valley and eastern districts during the following two or three days, attended by general rains from the Great Plains to the Atlantic, the falls becoming heavy to excessive in portions of the Gulf States, Ohio Valley, and to the northeastward.

The average pressure for the month was below normal in practically all portions of the United States, except locally in North and South Dakota and along the Pacific coast from northern California to Washington. In Canada pressure was likewise below normal from the Great Lakes eastward, but it was generally above in the more western districts. In the eastern districts of both the United States and Canada the monthly pressure was unusually low. In some cases the averages were the lowest ever known in April.

The severe barometric disturbances gave rise to numerous storms over southern districts, frequently of tornadic character and causing the loss of many lives, and much damage to property, full accounts of which will appear in other portions of this REVIEW. The greatest departure from the average pressure was located over the Great Lakes, and St. Lawrence Valley, where the pressure was low during much of the month. As a result the winds from the West Gulf States to the middle Atlantic coast were largely from the South or Southwest, while in the Upper Mississippi Valley and Northern Plains States they were northwest to west.

TEMPERATURE.

The month was marked by persistent cold throughout the greater portion in nearly all districts, and sharp falls in temperature occurred during the early days, particularly following the severe storm of the 4th to 5th, during which time the temperature fell to nearly 30° below zero in the northern mountain districts, and freezing weather was felt southward to the middle portions of the Gulf States, into central Texas, and over large portions of the far Southwest, causing much damage to early fruits and truck. The minimum temperatures observed during this cold wave, particularly on the morning of the 5th, were the lowest of record for April over wide areas between the Rocky Mountains and the Mississippi River, and from the Canadian boundary to the Rio Grande, and Texas coast. The cold wave extended eastward during the following few days, diminishing somewhat in intensity but at the same time giving over most of the country the lowest readings of the month. No severe cold was experienced during the middle and latter portions of the month, but it remained cold in nearly all districts, many stations, particularly in the northern sections, having only an occasional day with temperature above the normal. The week ending April 13 was particularly cold in the Ohio Valley and Great Lakes region, and those of the 20th and 27th in the Mountain and Plateau regions of the West.

The highest temperatures for the month were experienced from the 16th to the 22d over most districts from the Rocky Mountains eastward, and in the far West they were observed near the close. Maximum temperatures above 100° were reported locally from Texas and California, but no previous high records were reached.

The mean temperature for the month was less than normal in all parts of the country, save along the immediate Atlantic and Gulf coasts and at a few points near the coast of California. Over considerable areas in the Rocky Mountain region it was the coldest April, as a whole, in the past 50 years.

PRECIPITATION.

For the month, as a whole, the precipitation, except in a few instances, was far above normal in the States east of the Mississippi and south of the Great Lakes. The amounts were especially large in the middle Gulf States and portions of Florida and the Ohio Valley, where local stations reported total falls ranging frequently from 10 to 15 inches or more. Precipitation was also well above the normal over a wide area from the middle Mississippi Valley westward to California, and generally along the Pacific coast. Along the northern border from Lake Superior to Montana precipitation was less than usually occurs, and similar conditions existed from Texas and Oklahoma westward over New Mexico and Arizona. In portions of western Texas the precipitation was the least ever reported for April.

SNOWFALL.

Some marked variations were presented in the snowfall distribution usually associated with a mid-spring month.

During the Easter season, particularly on Easter Sunday, heavy snow, high winds, and severe cold, usually associated with the Christmas period, prevailed over a wide area from the Middle Rocky Mountains to the Great Lakes. The total snowfall during this period was in many cases the greatest ever known in April, and in some instances the fall was as great as that for the entire preceding winter.

Near the end of the second decade heavy snow fell over the middle Rocky Mountains and the adjacent plains, the depths frequently ranging from 10 to 20 inches over the lower elevations to nearly 100 inches in the high mountains of northern Colorado and southern Wyoming. Several lives were lost, due to the severity of the storms and much loss was sustained by the stock interests, mainly among lambs and calves, but also to older cattle weakened from exposure during the long cold winter and general lack of sufficient feed.

RELATIVE HUMIDITY.

Throughout the country as a whole the relative humidity was higher than normal, although in some sections surprising deficiencies were experienced. This was notably the case in portions of the Ohio Valley and southward over much of the Gulf States, where, despite the heavy and frequent precipitation and the saturated condition of the soil, the relative humidity averaged less than normal, and at some points distinctly so. Over Texas the dry conditions existing during the month were indicated by large deficiencies in the relative humidity, and there were slight deficiencies over the Pacific States and locally along the Atlantic seaboard.

STORMS AND WARNINGS—WEATHER AND CROPS.

STORMS AND WEATHER WARNINGS.

By EDWARD H. BOWIE, Supervising Forecaster.

[Washington, May 21, 1920.]

WASHINGTON FORECAST DISTRICT.

In this forecast district the month was noteworthy by reason of the frequency of alternations of fair and foul weather, low temperatures, and the excess in number and rapid movements of areas of high and low pressure. The month opened with a disturbance of large area and considerable intensity over the central Mississippi Valley, which storm moved rapidly northeastward and on the 3d disappeared in the region of Hudson Bay. It produced general rains east of Mississippi River during the 1st and 2d. On the 1st advisory warnings of strong winds were sent to open ports on Lake Michigan, and on the 2d cold-wave warnings were ordered for the Ohio Valley and the region of the Great Lakes and storm warnings were displayed on the Atlantic coast at and between Cape Hatteras, N. C., and Easport, Me. On the 3d the forecast stated that a storm that was then central over the Texas Panhandle would advance east-northeastward and be attended by general cloudiness and rains over nearly all parts of the Washington forecast district within the next 36 hours with a probability of snow in the upper Lake region. This disturbance moved as forecast and on the 4th, Easter Sunday, rains were general east of the Mississippi River and snow was falling on the Great Lakes. Moreover, on the 3d advisory warnings of snow and strong winds and gales were sent to open ports on Lake Michigan and small-craft warnings were displayed on the Mississippi, Alabama, and northwest Florida coasts. On the 4th northwest storm warnings were displayed on the east Gulf and on the Atlantic coast at and north of Jacksonville, Fla., and cold-wave warnings were distributed over the lower Ohio Valley, Tennessee, and the east Gulf States and over the Carolinas, Virginia, the District of Columbia, and Maryland.

On the morning of the 11th, when a disturbance was central over Kansas, it was forecast that this storm would move east-northeastward and be attended by rains and snows in the region of the Great Lakes and showers and thunderstorms in the Ohio Valley, Tennessee, and the east Gulf States the following night and Monday, the 12th, and by showers Monday, the 12th, in the Atlantic States. This forecast accurately described the conditions that actually occurred. Furthermore, on the 11th advices of gales and snows were sent to open ports on Lake Michigan and the afternoon of the 12th, storm warnings were displayed on the Atlantic coast at and between Jacksonville, Fla., and Eastport, Me.

A disturbance of moderate intensity was central the morning of the 15th over Kansas and its presence made necessary the issue of a forecast of general rains east of the Mississippi River during the succeeding 36 hours. On the morning of the 16th, the center of this distrubance was over Illinois and on the 17th over Virginia. In the meantime a disturbance of marked intensity moved rapidly southeastward from British Columbia, and on the morning of the 17th its center was over Colorado with every indication that it would move eastward and be attended by general rains over the eastern half of the country. The development over southern Canada of an area of high barometric pressure, however, prevented such a movement, and it was not until the 22d that this disturbance finally reached the Atlantic Ocean. It produced general rains, however, over much of the country east of the Rocky Mountains, and on the 20th severe local thunderstorms and tornadoes occurred in the East Gulf States and Georgia. This disturbance was followed by another that made its appearance in the Northwestern States on the 19th. It moved southeastward during the 20th, and the morning of the 21st its center was over northwestern Kansas, whence it moved east-northeastward and reached the Grand Banks on the 25th, attended by general rains over the Northern and Eastern States.

The last important storm of the month had its center on the morning of the 26th over Mississippi, whence it moved northeastward and disappeared north of the St. Lawrence River on the 29th. Storm warnings were displayed in connection with this disturbance on the Atlantic coast at and north of Block Island, R. I., and on Lakes Erie, Ontario, Huron, eastern and central Lake Superior, and extreme northern Lake Michigan.

WARNINGS FROM OTHER DISTRICTS.

Chicago Forecast District.—The frequent movement of well-marked storms over the district continued during the month of April. The storms were unusual, both in frequency and in intensity, for the season of the year. They were accompanied by considerable precipitation and, as their tracks were well to the south, the temperature was for the most part considerably below the monthly normal.

The month opened with the passage of a severe storm over the southern and eastern portions of the district, and this was immediately succeeded by another which passed from the middle Rocky Mountain region directly eastward, taking an even more southerly course than its predecessor.

Both of these storms were accompanied by widespread precipitation and abnormally large snowfalls, many stations reporting amounts exceeding the previous April record. On the 4th and 5th several stations reported minimum temperatures, also breaking the April record.

At the beginning of the month vegetation had not developed sufficiently in the district to call for frost warnings, except in the more southerly sections. On the 1st advices for freezing temperatures were sent to Kansas and western Missouri, and on the 2d to the entire States of Kansas and Missouri, and warnings of frost to southern Illinois.

On the 3d a cold-wave warning was sent to southern Kansas, and on the morning of the 4th warnings of frost or freezing temperature to Missouri, Kansas, and extreme southern Illinois.

On the night of the 1st a warning of impending gale with squalls was phoned to local shipping interests on Lake Michigan, supplementing the general advisory message for the Lake issued from Washington. Another warning was issued to local shipping interests on the night of the 3d and the morning of the 4th.

On the morning of the 3d advices to live-stock interests were sent to the States of Kansas, Nebraska, and west Missouri, and special cold-wave warnings to southern Kansas. All these special forecasts for low temperature and stormy conditions were fully verified.

On the morning of the 10th another storm was apparently developing in the Plateau and Rocky Mountain regions promising a repetition of the severe conditions which prevailed the previous week. Advices to live-stock interests were immediately wired to points in the States of Wyoming, South Dakota, and the northern portions of Nebraska and Kansas, and these undoubtedly proved timely as the snow was heavy and the gales were strong from the north with falling temperature. On the night of the 10th warnings were issued to vessel interests on southern Lake Michigan in conformity with a message from Washington for strong easterly winds with rain or snow.

On the morning of the 11th cold-wave warnings were issued to Kansas and points in western Missouri, but these failed of verification, except in western Kansas, because of the unusually rapid movement eastward of the disturbance. At the same time heavy-snow warnings were issued for several points in the middle West, but the precipitation which was largely in the form of heavy snow in the Central Plains States was in the form of rain in the sections farther east. This storm took a course directly eastward over southern Missouri and the Ohio Valley.

On the morning of the 12th warnings for frost or freezing temperature were sent to the States of Illinois, Missouri, Kansas, and Nebraska, and on the morning of the 13th warnings of frost to Illinois and eastern Missouri, and these were fully verified.

Another storm developed in the far West on the 15th–16th, and advices to live-stock interests were sent to Wyoming on the morning of the 16th and to Nebraska and Kansas on the morning of the 17th. Severe conditions also attended the movement of this storm and doubtless the warnings were quite timely.

Warnings of frost or freezing temperature were again sent to the States in the southern and central portions of this district on a few days during the balance of the month, and these were justified as shown by ensuing conditions.

Advices to live-stock interests were issued to points in Montana and Wyoming on the 28th, and to Wyoming and Nebraska on the 29th, in advance of falling temperature with northerly winds and rain turning to snow.

A special effort was made during the month to keep live-stock interests fully advised as to cold, wet weather, whether with snow or rain, because of the lambing and shearing season.—*H. J. Cox.*

Denver Forecast District.—The month was unusually cold in the northern and eastern parts of the district. Three storms of marked intensity crossed the district during the month. The first of these was followed by remarkably cold weather for the season on the eastern slope, and the loss of the fruit crop in the Pecos Valley in eastern New Mexico. The storm reached the Texas Panhandle on the morning of the 3d, with increasing intensity. Cold-wave warnings were issued for eastern New Mexico and much colder weather predicted for Colorado. Live-stock warnings were issued for eastern Colorado and northern New Mexico. The cold-wave warning was verified in eastern New Mexico, an unprecedented freeze occurring in the Pecos Valley. At Roswell the remarkably low temperature reading of 18° above zero was recorded and the temperatures in eastern Colorado ranged from zero to 10° above zero. The second storm crossed the district at the end of the first decade and resulted in freezing temperatures in a large area for which warnings had been issued. The storm that was central in southeastern Colorado on the morning of the 17th was unusually severe in eastern Colorado for the time of the season. The live-stock warnings issued for eastern Colorado on the morning of the 17th were timely as freezing temperatures and heavy snows covered nearly all of Colorado during the following 24 hours. Live-stock warnings were extended to cover eastern New Mexico on the evening of the 17th and the morning of the 18th, but the resulting weather conditions were not so severe in that State. Freezing temperature warnings were also issued for large areas on several other dates and were generally verified.—*Frederick W. Brist.*

New Orleans Forecast District.—Conditions were more intense than is usual during April. A number of barometric depressions, moving far southward before they turned to the east or northeast, passed over the district and were followed by short periods of unseasonably cold weather.

Northwest storm warnings were issued for the Texas coast on the morning of the 4th because of a disturbance that was passing eastward, followed by considerably higher pressure. The warnings were fully verified on the east coast of Texas but not on the west coast, and were ordered down at 8.30 p. m.

Unusually low barometer was charted over the west Gulf States on the 8 p. m. map of the 17th, the center of

the depression being over northern Texas. Southeast storm warnings were displayed on the Louisiana coast and southwest warnings on the east coast of Texas. As the disturbance tended to fill up and diminish in intensity, the warnings were not verified.

On the morning of the 26th an area of high pressure was advancing southeastward from the Rocky Mountain region and the Plains States, preceded by low pressure in the lower Mississippi Valley and on the Texas coast. Northwest storm warnings were ordered for the Texas coast and were verified.

Small-craft warnings were displayed on the Louisiana coast on the 1st, 4th, and 6th, and on the Texas coast on the 6th and 17th, and were justified.

No general storm occurred without warnings.

On April 1 and 2 a disturbance moved northeastward from the southern Plains States to the Lake region and was followed by frost in northern Texas as far east as Dallas, with freezing in northwestern Texas and Oklahoma. Warnings of frost or freezing temperature were issued 24 hours in advance of occurrence for the northwestern portion of the district, but for not quite all the area where frost occurred, the movement of the conditions being unusually rapid for the season.

On account of intense conditions on the morning of the 3d, when a disturbance overlaid the northwestern portion of the district, with a strong barometric gradient on the northern side, freezing was forecast for Oklahoma, the northern portion of west Texas, the northwestern portion of east Texas, and northern Arkansas. Midday special observations were obtained and a cold-wave warning was issued for the northwestern portion of the district. The warning was verified and freezing weather occurred as forecast. A minimum temperature of 13° was registered at Amarillo on the 4th.

Warning of frost in the interior of Louisiana and to the Texas coast except in the lower Rio Grande Valley, with freezing or lower in Oklahoma, northern Texas, Arkansas, and extreme northern Louisiana, was issued on the morning of the 4th. Conditions occurred generally as forecast. Frost was observed as far south as Houston, Tex., on the morning of the 5th, and the lowest temperature of record for the season occurred at Galveston, Tex., Shreveport, La., and in Arkansas.

On the morning of the 11th a deep depression was central over extreme southwestern Kansas and a moderate area of high pressure to the northward was moving south. Cold-wave warnings were issued for the northwestern portion of the district. The cold wave reached the Texas Panhandle on the morning of the 12th, but freezing did not extend over southern Oklahoma, and did not reach Bentonville, Ark., until the morning of the 13th.

Besides the warnings already mentioned, warnings of frost or freezing temperature in some portion of the district, in the northern portion as a rule, were issued on the 5th, 6th, 9th, 11th, 13th, 17th, 18th, 22d, 25th, 26th, 27th, and 30th, and nearly all were verified. Warnings to live-stock interests were issued on the 3d, 11th, and 17th for the northwestern portion of the district.

Fire-weather warnings for the forest reserves of Oklahoma and Arkansas were issued on the 3d, 14th, 17th, and 21st, and were fully justified, the wind and weather occurring as predicted in nearly every particular.—*R. A. Dyke.*

San Francisco Forecast District.—No severe storms occurred in this district during April. Sufficient rain fell for present needs, though the amount was below normal in California and the greater part of Nevada. In the North Pacific States it was heavier than usual and in the lower Columbia River Valley the excess amounted to more than an inch.

There were two wet spells in California and Nevada, both of which covered a period of about three days. The first began on the 8th and was caused by a LOW over western Oregon that moved southeastward. The second, beginning on the 13th, was from a LOW over British Columbia that moved south to Nevada, where it developed sufficient intensity to cause well distributed showers in the southern portion of the district.

During these two wet spells a large amount of snow was deposited in the northern Sierra Nevada Mountains. This was just what was needed to improve the water supply for irrigation and power purposes, as before it fell the snowfall was far below normal and even now it is considered insufficient for all requirements during the latter part of the summer.

After the showery period near the middle of the month, the weather in this district was controlled by the North Pacific HIGH, which was most in evidence along the coast north of Eureka, Calif. Near the close of April a LOW from British Columbia moved south to Nevada, but it did not develop sufficient energy to cause any precipitation of consequence in the southern portion of the district.

Storm warnings were issued on the 2d and 3d for the North Pacific coast, and quite frequently between the 8th and 19th along the north California coast for winds that were more local than general in character. Small-craft warnings were displayed at San Francisco on the 15th. It is thought the storm warnings were timely and of benefit to mariners.

During the forepart of the month frost warnings were issued for the interior of northern California on several occasions, and during the latter half they were issued quite frequently for different localities in the North Pacific States. It is believed they were all justified and that no damaging frosts occurred without warnings.

Live-stock warnings for cold rains, with snow in the mountains, were distributed to stockmen on the 19th and 29th, both of which it is believed were fully verified.—*E. A. Beals.*

RIVERS AND FLOODS, APRIL, 1920.

ALFRED J. HENRY, Meteorologist in Charge River and Flood Division.

[Weather Bureau, Washington, June 2, 1920.]

FLOODS, APRIL, 1920.

This report deals with floods which began in March and continued into April. (See this REVIEW **48:** 176–178.

Floods in New England.—The melting of the heavy snow cover in New England in connection with the current precipitation of the month produced high water of more than the usual duration. The Connecticut at Hartford was above flood stage from the 1st to the 9th and again from the 14th to the 21st, and finally from the 22d until the close of the month. The Merrimac reached a stage of 21.68, the highest since 1902.

Frequent light floods in the rivers of the Carolinas served to prolong high water in the lower reaches

of the streams in those States, particularly in South Carolina.

Moderate floods also prevailed in the rivers of Georgia and Mississippi, due to frequent short periods of rain. The distinctive feature of these floods was the sustained high water and in places the overflow of bottom lands as in the Tombigbee Valley from near Demopolis to the mouth of the river and in the Black Warrior Valley below Tuscaloosa. At the close of the month considerable portions of the lowlands along the Tombigbee remained flooded.

There were no floods of importance in the West Gulf Drainage.

Great Lakes Drainage.—The only flood of importance in this district occurred in the Maumee and its tributaries during the period April 21–24. There was no serious damage.

Mississippi Basin—Ohio Drainage.—On the 1st the rainfall was general and more or less heavy over the watershed of the Cumberland and the Tennessee. The rain continued on the next day and was also general and much heavier, averaging more than 3.5 inches above Decatur, except in the northern headwater streams, where it was about 2.25 inches. As a result the Tennessee above Decatur rose sharply on the 2d, the rise continuing and increasing on the 3d; on this date the crest of the upstream rise passed Knoxville and Loudon. No rain fell on the 3d, but on the 4th moderate rains again fell over the watershed above Decatur.

On the morning of the 2d the official in charge of the Chattanooga district issued warnings for his entire district. The crest stage for Chattanooga was tentatively placed at not less than 41 feet, and the city commissioner of fire and police for Chattanooga was advised that immediate action should be taken looking to the removal of the people living below the 41-foot mark on the gage. This was done and a general distribution of the warning was made by means of bulletin, publication in the city papers, and personal replies by telephone.

The river at Chattanooga rose from 17.2 feet on the 1st to a crest of 43.6 feet at 9 a. m. of the 5th, 26.4 feet in a little more than four days. This rise passed slowly downstream, flattening out in the lower reaches so that when the Ohio was reached the increased flow from the Tennessee was not sufficient to check the fall which had already set in in the trunk stream.

The more or less heavy rains of the 20th–26th caused the northern tributaries to reach and pass flood stage. Earlier in the month the Tennessee and Cumberland had been in flood, but at no time did the flood waters from both north and south tributaries synchronize. The principal flood in the Ohio was that of the 22d–25th in the lower reaches of the stream. The river at Cairo was at a stage of 51.1 feet on the 1st and did not fall below flood until the 19th, remaining below only six days, when it again rose to above flood stage, due to the rains of the 19th–21st and continued above flood stage at the close of the month. Floods in the lower Ohio have been usually frequent during the last six months.

The April high water along the lower Ohio seriously delayed the planting of the lowlands to corn.

Mississippi Main Stream.—At the close of March the Mississippi was in flood from Winona, Minn., to La Crosse, Wis., also from Quincy, Ill., to Helena, Ark. At the close of April the river was above the flood stage from New Madrid, Mo., to the mouth, and also in the stretch between Hannibal, Mo., and Alton, Ill.

The flood in the upper Mississippi which was in progress on April 1 was due to a heavy discharge from the rivers of Minnesota and Wisconsin, augmented by moderately heavy rains during the first few days of April. Timely warnings were issued by the Weather Bureau officials along the stretch of river concerned, thereby enabling precautionary measures to be taken and the removal of property from the threatened areas. Below is a condensed summary of the flood in the Dubuque and Davenport, Iowa, and Hannibal, Mo., districts:

FLOOD OF MARCH-APRIL, 1920, DUBUQUE, IOWA, DISTRICT.—This Mississippi flood was the worst in this district since 1888, and has been exceeded in the last 50 years only by the floods of June, 1880, and May, 1888. It was the earliest spring flood of such magnitude of which there is a record. In rapidity of rise it is comparable with the flood of June 1880. The total rise in each of these two floods between 13 and 14 feet continued over a period of more than two weeks.

In the flood of June, 1880, the maximum rise was 6 feet in three days, while in the 1920 flood the maximum rise was the same, with this important difference, viz. it came during the last part of the rise instead of the first part, as in 1880.

Most of the flood waters came from the headwaters of the Mississippi. The Wisconsin River was above flood stage during the same period, a maximum stage of 15 feet being recorded at Portage on March 31. This flood added about 1.5 feet to the peak of the Mississippi River flood between Dubuque and Prairie du Chien. Heavy and general rains on April 1 also added 0.5 or 0.6 feet to the peak between Prairie du Chien and La Crosse. With these exceptions the flood waters came wholly from the region north of La Crosse.

In two particulars the floods of June, 1880, and March-April, 1920, were not comparable. The cause in 1880 was exceedingly heavy rains early in June over the headwaters of both the Mississippi and Wisconsin Rivers. The cause in 1920 is probably indicated by the following paragraph from the National Snow and Ice Bulletin, Minnesota report, March 23, 1920: "Latter part of week abnormally warm and snow disappearing rapidly." Warm weather, the disappearance of snow in northern Minnesota, and the appearance of the flood at St. Paul were almost simultaneous. From Prairie du Chien to La Crosse the flood peak in 1880 was much higher than in 1920, but at Dubuque it was only 0.7 of a foot higher. The following table illustrates the difference:

	La Crosse.	Lansing.	Prairie du Chien.	Dubuque.
Peak, June, 1880	16.2	.....	21.5	21.7
Peak, March-April, 1920	14.2	17.2	19.6	21.0
Difference	2.0	.....	1.0	0.7

WARNINGS.—On Monday, March 29, nine days before the peak of the flood reached Dubuque, flood warnings were issued for the entire district from the vicinity of Dubuque to immediately below La Crosse. On this date stage of water was 11.5 feet at Dubuque, 10.8 feet at Prairie du Chien, and 11.3 feet at Lansing. Warnings were generally heeded, and movable property, such as cordwood in large quantities, live stock, farm machinery, etc., was removed from the islands and lowlands of the Mississippi throughout the section.

Later in the week, when it became certain that a flood of great magnitude was approaching, whatever could be done to prevent damage was done. Upon advice from this office some of the factories raised machinery to higher levels, and a number of firms within the wholesale district of Dubuque removed their stocks from cellars and basements.

This office was able to render valuable service over more than a 10-day period. Information was given daily over the phone to several hundred people. On Sunday, April 4, the office was open from 6 a. m. until 10 p. m., and the phone was in use every moment of the time. We were able to advise many families not to move and many business houses not to move stocks or machinery after ascertaining how many inches more of a rise they could stand. On this date a northeasterly gale added to the difficulties of the railroads on the west bank of the Mississippi. After that date winds were generally more favorable.—*J. H. Spencer.*

DAVENPORT DISTRICT.—The rapid melting of an unusually heavy accumulation of snow in Minnesota and Wisconsin, most of which remained on the ground until about the middle of March, when it was taken off quickly by the high temperatures and heavy rains that attended a succession of storms that moved across the upper Mississippi watershed during the latter half of the month and the first day or two of April, resulted in the highest stages in the Davenport River district since the year 1892.

On March 31 the following flood warning was issued: "The Mississippi will reach or exceed the flood stage within the next week or 10 days at all points between Dubuque and Muscatine. Approximately the fol-

lowing maximum stages are now indicated: Clinton, 17 feet, April 8; Le Claire, 11.5 feet, April 9; Davenport, 15 feet, April 9; Muscatine, 16.5 feet, April 10. All threatened property should be removed or protected."

The flood crest reached all stations in the district on the dates named in the forecasts, with the following highest stages: Clinton, 19 feet; Le Claire, 13.4 feet; Davenport, 17.1 feet. A break in the levee at Muscatine, 12 miles below the city, occurred during the night of April 6-7, when the stage was approximately 17 feet. About midnight of the 8th-9th a break occurred on the Illinois side, opposite Muscatine, when the gage reading was 18 feet, and the stage fell 0.3 foot, or to 17.7 feet, by 7 a. m. of the 9th, and to 17.5 feet at 7 a. m. of the 10th. At noon of the 10th the stage had again risen to 17.7 feet, when further breaks in the levees on the Illinois side caused a fall of 0.7 foot during the next 18 hours, the gage reading 17 feet at 7 a. m. of the 11th.

Within a day or two after the arrival of the flood crest, the river began to fall at a moderately rapid rate, passing below the flood stage at Clinton on April 15, at Le Claire by the 18th, at Davenport on the 14th, and at Muscatine on the 16th.

Immediately after the first flood warning was issued a large force of men was employed at Bettendorf, Iowa, about a mile above Davenport, in strengthening the levees at that place which protect the large plants of the Bettendorf Co. and the Zimmerman Steel Co. For about a week before the arrival of the flood crest work in the factory of the Bettendorf Co. was suspended and the forces of men from the shops were engaged continuously, day and night, in preparing the levees to withstand a 17-foot stage. These efforts were successful, the loss being confined to that due to suspension of business.

On account of the accurate warnings issued well in advance, losses from Clinton to Davenport, inclusive, were comparatively small, practically all movable property having been placed out of danger. Considerable inconvenience was caused by the flooding of cellars near the river front with seep water, which in some cases rendered heating plants useless, and dwellers in the poorest class of houses along the water front were compelled to abandon their homes.

Notwithstanding the heavy losses to agricultural interests in the bottom lands on both sides of the river near Muscatine, caused by the failure of the levees to hold, the strenuous efforts which were begun when the first flood warning was issued to maintain the levee that protected the city itself were successful, the damage within the city limits not exceeding $50,000, due, mostly, to suspension of business.

Opposite Muscatine, in Illinois, about 62,800 acres of exceptionally rich agricultural land were flooded in the Drury, Union, Bay Island, and No. 13 drainage districts by the breaking of the levees, while 23,000 acres of land, mostly devoted to truck raising, were flooded on Muscatine Island, immediately below the city. Although the total loss in those sections, including the loss of prospective crops, will exceed $3,500,000, only about $18,400 worth of movable property was destroyed, of which there was $5,000 worth of corn that had been left in the shock.

It is now thought that it will be impossible to plant the flooded lands on the Illinois side and that the loss to prospective crops will amount to $50 per acre. On Muscatine Island, where the natural drainage is much better, the loss will be only partial and will hardly exceed $10 per acre.—*J. M. Sherier.*

HANNIBAL DISTRICT.—The melting snow and rains during the last half of March caused a slight flood in the lower Des Moines River and the beginning of a severe flood in the Mississippi.

Advisory warnings for the territory from Ottumwa to Alexandria were issued on March 16 and again on March 25 and 26. Warnings for the reach from Keokuk to Louisiana were issued on March 25, and for Keithsburg on March 30. Warnings for some portion of the sistrict were issued on April 2, 3, 5, 6, 7, 8, 9, 10, 11, 21, and 22.

During the period from April 2 to 13 forecasts from three to six days in advance were made and were verified to within 0.1 to 0.3 of a foot. The only material failure was caused by the breaking of two levees near Muscatine, Iowa, which caused a delay in the flood wave and a lessening of crest stages for some distance below the break.

The flood seemed to be over by April 17, when heavy rains on April 18 and 19 in northeastern Missouri, the Des Moines, Skunk and Cedar valleys in Iowa, caused more serious flood conditions from Quincy to Louisiana than had occurred from the flood waters of the upper Mississippi River.

There was no preventable loss.—*B. L. Waldron.*

While the Mississippi in the St. Louis district reached and passed slightly above the flood stage at Grafton, Alton, and Chester, Ill., no material damage was caused. The river was in flood at Cairo and below from the discharge of the Ohio as before stated. At Memphis the crest of the first rise, 40.3 feet, was reached on the 5th; then followed a slow decline to 35 feet on the 25th and 26th, only to be followed by another rise which continued into May.

At Vicksburg the river passed above flood stage on the 4th with a crest of 50.8 feet on the 20th. At the close of the month the river was almost stationary and above the flood stage. At this writing (June 1) it is at a stage of 48.3 feet and falling slowly.

NEW ORLEANS DISTRICT.—On March 24, when the river stage at Cairo was 48.5 feet, and at Natchez was 35.6 feet, the first warning for the Mississippi below Vicksburg was issued, stating that the flood stage, 46 feet, would be passed at Natchez by April 10. On March 30, warning was issued that the flood stage would be passed also at Baton Rouge, Donaldsonville, and Melville by April 10. On April 1 the following warning was issued:

"The Mississippi River below Vicksburg, and the Atchafalaya, will rise until the latter part of April. Water now in sight indicates at least the following stages: Natchez, 49.5 feet by 20th; Baton Rouge, 37.5 feet, and Melville, 39 feet by 22d; Donaldsonville, 29.5, New Orleans 18 feet and Simmesport, 41 feet by 24th."

This warning was modified from time to time as the current weather conditions demanded. The flood is still in progress.—*I. M. Cline.*

Agricultural Lands Overflowed.—**The greatest single overflow was due to the failure of two levees—one on the Illinois side of the Mississippi opposite Muscatine, Iowa, the other on the Iowa side and also opposite Muscatine. About 86,000 acres were overflowed as a result of these breaks.**

All of the lowlands between Keokuk and Hannibal not protected by levees were overflowed.

There was also considerable overflow in Pike, Knox, and Daviess Counties, Ind., along the lower White River and along the Ohio in the Evansville, Ind., district. Some damage was done the oat and wheat crop in Indiana. A levee north of Vincennes, Ind., broke on April 3, flooding about 10,000 acres of bottom lands. Bottom lands were also overflowed in western Alabama.

High water in the Mississippi coupled with freshets in the Ouachita and Red Rivers made conditions along the lower Black River of Mississippi critical on account of backwater.

The only break in the levees protecting the lowlands along the lower Mississippi River occurred on the 17th about 75 miles below New Orleans. This break was promptly repaired.

HEAVY RAINS AND FLOODS IN BLACK HILLS, S. DAK.

Rain began Monday afternoon May 10, and was almost continuous until Wednesday night, May 12, which, following the unprecedented snowfall of April 17 and 18, caused the greatest floods in Rapid Creek—a tributary of Cheyenne River—since 1907, and all streams in the Black Hills region were at flood stages. The total rainfall at Rapid City for the period, 10th to 12th, was 4.75 inches.

As a result of the melting of heavy snows and the moderate rainfall during the first part of May the creek was approximately 3½ feet above the normal on May 10, at which time it began rising. By Tuesday morning, May 11, the water had spread over the low flats and the conditions were fast becoming serious. Due to the heavy fall of rain during the night and morning of May 11, telephonic reports from upstream indicated that the river was steadily rising, and at 9 a. m. the Weather Bureau observer issued warnings to the city authorities to prepare for a further rise of 2 feet, or a stage of 6 feet above the normal, and that conditions were dangerous to people living on the lowlands. These people were immediately notified and removed from their homes. The crest of the flood reached Rapid City about noon May 11 and the stage of water was approximately 6 feet above the normal. Many homes were surrounded by water but no lives were lost.

About 20 bridges on the Rapid City, Black Hills & Western Railroad were either damaged or washed out, and practically all the private and county bridges on the stream were taken out. Other railroads suffered in like manner. It is estimated that from $75,000 to $100,000 will be required to put the railroads in good condition aside from loss of service from two weeks to a month. Six persons lost their lives in this flood outside of Rapid City.—*H. N. Johnson.*

Estimated loss by flood, April, 1920.

River and district.	Tangible property—Bridges, roads, buildings, etc.	Crops. Matured.	Crops. Prospective.	Suspension of business.	Farm buildings, machinery, live stock, etc.	Estimated value of warnings.
Mississippi:						
Hannibal district	$5,500	$3,000	$50,000	$800	.....	$62,000
Davenport district	136,040	8,500	3,374,800	185,775	$85,900	2,501,300
Dubuque district	88,000	1,000	500	5,500	5,000	125,000
White (Ind.):						
Indianapolis district	15,000	2,000	25,000	10,000	.....	(1)
Wabash:						
Terre Haute district	2,000	.....	200,000	2,500	.....	100,000
French Broad:						
Asheville district	32,000	5,000	500	600	1,000	.....
Santee:						
Columbia district	550	.....	.....	600	.....	60,000
Peedee:						
Charleston district	5,000	.....	.....	.....	.....	.....
Pearl and West Pearl:						
Meridian district	4,000	1,000	750	2,000	1,000	5,000
Alabama:						
Montgomery district	.....	1,050	.....	1,100	300	7,000
Cumberland:						
Nashville district	.....	.....	5,000	15,500	.....	10,500
Hudson:						
Albany	300	.....	.....	.....	.....	500
Total	288,390	21,550	3,656,550	224,375	93,200	2,815,500

(1) Unknown.

Flood stages for the month of April, 1920.

River and station.	Flood stage.	Above flood stages—dates. From—	Above flood stages—dates. To—	Crest. Stage.	Crest. Date.
ATLANTIC DRAINAGE.					
Connecticut:	*Feet.*			*Feet.*	
White River Junction, Vt.	13	(2)	7	17.6	[2] 26
Do	13	14	(1)	18.4	24
Hartford, Conn.	16	(2)	9	22.5	[2] 30
Do	16	15	(1)	20.2	16
Albany:					
Hoosick Falls, N. Y.	3	10	11	3.1	10,11
Susquehanna:					
Oneonto, N. Y.	12	1	4	12.8	1,3
Neuse:					
Neuse, N. C	14	29	29	14.2	29
Peedee:					
Cheraw, S. C.	27	6	7	28.0	5
Santee:					
Rimini, S. C.	12	(2)	(1)	17.2	9,10
Ferguson, S. C.	12	(2)	(1)	14.0	3
Catawba:					
Catawba, S. C.	12	3	3	12.2	3
Wateree:					
Camden, S. C.	24	5	7	26.6	5
Broad:					
Blairs, S. C.	15	6	6	15.2	6
Saluda:					
Pelzer, S. C.	7	6	6	7.6	6
Edisto:					
Chappells, S. C.	14	(2)	1	17.0	[2] 31
Do	14	3	7	15.5	6
Edisto, S. C.	6	2	6	6.4	4,5
Broad (Ga.):					
Carlton, Ga.	11	2	2	11.0	2
Ocmulgee:					
Abbeville, Ga.	11	2	13	14.7	4
Lumber City, Ga.	15	6	12	16.8	7
EAST GULF DRAINAGE.					
Apalachicola:					
Blountstown, Fla.	15	(2)	20	17.6	8
Do	15	30	(1)	15.0	30
River Junction, Fla.	12	(2)	(1)	23.4	7
Flint:					
Albany, Ga.	20	4	9	26.2	5
Bainbridge, Ga.	25	7	10	27.7	8
Chattahoochee:					
Alaga, Ala.	30	1	6	35.0	5
Do	30	30	(1)	30.3	30
Alabama:					
Montgomery, Ala.	35	3	13	45.6	5
Selma, Ala.	35	(2)	16	48.8	7
Do	35	29	(1)	37.4	30
Coosa:					
Rome, Ga.	30	5	6	30.5	5
Gadsden, Ala.	22	2	14	27.4	10
Lock No. 4, Lincoln, Ala.	17	1	15	23.0	3
Wetumpka,	45	3	5	46.1	4
Etowah:					
Canton, Ga.	11	2	2	14.6	2
Oostanoula:					
Resaca, Ga.	25	3	7	32.0	4
Cahaba:					
Centerville, Ala.	25	2	2	26.6	2
Do	25	21	21	26.0	21
Tombigbee:					
Aberdeen, Miss.	33	4	5	34.7	4
Demopolis, Ala.	39	(2)	(1)	61.6	10
Black Warrior:					
Tuscaloosa, Ala.	46	2	7	61.3	3
Do	46	27	28	49.9	28

[1] Continued into May. [2] March.

Flood stages for the month of April, 1920—Continued.

River and station.	Flood stage.	Above flood stages—dates. From—	Above flood stages—dates. To—	Crest. Stage.	Crest. Date.
EAST GULF DRAINAGE—continued.					
Pearl:	*Feet.*			*Feet.*	
Edinburg, Miss.	21	5	6	22.4	5
Jackson, Miss.	20	(2)	21	29.0	11
Do	20	27	(1)	24.1	31
Columbia, Miss.	18	14	14	18.8	14
Do	18	29	(1)	21.7	30
West Pearl:					
Pearl River, La.	13	(2)	20	14.7	17
Do	13	28	(1)	13.4	28
GREAT LAKES DRAINAGE.					
Maumee:					
Fort Wayne, Ind.	15	21	26	21.5	23
Napoleon, Ohio	10	23	23	10.2	23
St. Joseph:					
Montpelier, Ohio	10	21	24	13.7	22
Auglaize:					
Defiance, Ohio	10	23	23	11.0	23
Sandusky:					
Upper Sandusky, Ohio	13	21	22	14.5	21
Tiffin, Ohio	8	22	22	8.6	22
Fremont, Ohio	10	22	23	12.4	22
MISSISSIPPI DRAINAGE.					
Ohio:					
Cincinnati, Ohio	50	22	25	52.6	23
Louisville, Ky.	28	24	24	28.5	24
Cloverport, Ky.	40	23	29	44.3	25
Henderson, Ky.	33	24	(1)	39.1	28,29
Evansville, Ind.	35	23	(1)	40.8	28
Mount Vernon, Ind.	35	(2)	1	43.2	[2] 26
Do	35	24	(1)	40.5	29
Shawneetown, Ill.	35	(2)	2	46.0	[2] 27
Do	35	25	(1)	43.0	30
Cairo, Ill.	45	(2)	17	51.4	[2] 31
Do	45	25	(1)	49.2	30
Little Kanawha:					
Glenville, W. Va.	22	21	21	22.5	21
Muskingum:					
Zanesville, Ohio	25	22	22	26.7	22
McConnelsville, Ohio	22	21	24	25.7	22
Tuscarawas:					
Norris Point, Ohio	8	18	24	11.7	22
Coshocton, Ohio	8	17	24	14.6	22
Walhonding:					
Walhonding, Ohio	8	17	23	12.0	21
Hocking:					
Athens, Ohio	17	21	22	19.2	21
Scioto:					
Larue, Ohio	11	17	23	14.5	21
Prospect, Ohio	10	18	24	14.8	22
Bellpoint, Ohio	9	17	17	10.4	17
Do	9	21	22	12.0	21
Dublin, Ohio	8	21	21	8.5	21
Circleville, Ohio	10	18	23	15.0	22
Chillicothe, Ohio	14	19	24	20.6	23
Olentangy:					
Delaware, Ohio	9	17	17	9.4	17
Do	9	21	22	11.6	22
Licking:					
Falmouth, Ky.	28	20	22	33.4	21
Miami:					
Sidney, Ohio	12	21	21	12.8	21
Tadmor, Ohio	12	21	22	15.5	21
Hamilton, Ohio	12	21	22	14.1	21
Mad:					
Springfield, Ohio	10	21	21	10.7	21
Stillwater:					
West Milton, Ohio	7	21	22	12.7	21
Green:					
Lock No. 4, Woodbury, Ky.	33	3	7	37.4	5
Do	33	23	24	34.9	23
Lock No. 2, Rumsey, Ky.	34	25	(1)	35.5	29,30
Barron:					
Bowling Green, Ky.	20	2	4	25.0	4
Wabash:					
Bluffton, Ind.	12	18	22	12.9	19
Lafayette, Ind.	11	18	25	21.3	22
Terre Haute, Ind.	16	20	28	21.5	24
Vincennes, Ind.	14	23	(1)	20.0	26
Mount Carmel, Ill.	15	22	(1)	23.6	28,29
White:					
East Fork—					
Decker, Ind.	18	24	(1)	24.0	28
Shoals, Ind.	20	23	28	28.6	26
West Fork—					
Anderson, Ind.	12	21	22	13.2	21
Noblesville, Ind.	14	21	22	15.7	21
Elliston, Ind.	19	21	26	26.6	23
Cumberland:					
Carthage, Tenn.	40	4	5	42.8	4
Nashville, Tenn.	40	3	8	42.1	7
Clarksville, Tenn.	46	4	9	46.6	5
Lock D, Dover, Tenn.	49	6	10	49.7	8,9
Tennessee:					
Knoxville, Tenn.	12	2	5	26.7	3
Loudon, Tenn.	25	3	3	27.5	3
Chattanooga, Tenn.	33	3	7	43.6	5
Bridgeport, Ala.	24	4	8	29.2	6
Guntersville, Tenn.	31	3	11	38.8	8
Decatur, Ala.	21	5	11	23.1	9
Florence, Ala.	18	2	13	23.5	10
Riverton, Ala.	32	2	15	45.5	10
Savannah, Tenn.	40	4	15	46.7	12
Johnsonville, Tenn.	31	4	17	35.9	14

[3] Continued from March.

Flood stages for the month of April, 1920—Continued.

River and station.	Flood stage.	Above flood stages—dates. From—	To—	Crest. Stage.	Date.
MISSISSIPPI DRAINAGE—continued.					
French Broad:	*Feet.*			*Feet.*	
Penrose, N. C.	13	2	5	16.7	3
Asheville, N. C.	4	2	6	7.1	2
Dandridge, Tenn.	12	3	3	18.7	3
Big Pigeon:					
Newport, Tenn.	6	2	2	17.0	2
Holston:					
Rogersville, Tenn.	14	3	3	15.0	3
North Fork—					
Mendota, Va.	8	2	2	8.0	2
Clinch:					
Kingston, Tenn.	25	3	4	27.0	3
Little Tennessee:					
McGhee, Tenn.	20	2	3	30.5	2
Hiwassee:					
Charleston, Tenn.	22	2	5	30.5	3
Duck:					
Columbia, Tenn.	30	2	4	33.6	3
Mississippi:					
Winona, Minn.	16	(2)	1	16.0	1
La Crosse, Wis.	12	(2)	7	14.2	2
Prairie due Chien, Wis.	18	3	8	19.6	4,5
Dubuque, Iowa.	18	3	12	21.0	7
Clinton, Iowa.	16	6	15	19.0	8
Le Claire, Iowa.	10	4	17	13.4	9
Davenport, Iowa.	15	6	14	17.1	9
Muscatine, Iowa.	16	6	13	18.0	8
Keithburg, Ill.	12	5	20	14.2	10
Keokuk, Iowa.	14	3	25	16.8	11
Warsaw, Ill.	17	4	25	19.8	21
Quincy, Ill.	14	[2] 27	29	19.2	22
Hannibal, Mo.	13	(2)	(1)	19.5	22
Louisiana, Mo.	12	(2)	(1)	17.5	23
Grafton, Ill.	18	(2)	(1)	22.4	25
Alton, Ill.	21	(2)	(1)	25.1	24
Chester, Ill.	27	(2)	2	27.3	1
Cape Girardeau, Mo.	30	(2)	5	32.2	1, 2
Do.	30	10	15	30.7	12
Do.	30	25	28	30.5	26
New Madrid, Mo.	34	(2)	21	40.2	1
Do.	34	24	(1)	37.9	30
Memphis, Tenn.	35	(2)	(1)	40.3	5
Helena, Ark.	42	(2)	(1)	50.1	8, 9
Greenville, Miss.	42	4	(1)	47.0	16
Vicksburg, Miss.	45	4	(1)	50.8	19–28
Natchez, Miss.	46	9	(1)	51.5	28
Baton Rouge, La.	35	12	(1)	40.2	30
Donaldsonville, La.	28	13	(1)	31.5	28–30
New Orleans, La.	18	15	(1)	19.6	28–30
Arkansas City, Ark.	42	.....	.....	54.0	11
Wisconsin:					
Portage, Wis.	14	(2)	3	14.9	[2] 31
Des Moines:					
Ottumwa, Iowa.	10	20	21	12.0	21
Illinois:					
Morris, Ill.	13	19	26	17.8	21
Peru, Ill.	14	(2)	(1)	22.0	23
Henry, Ill.	7	(2)	(1)	16.2	24
Peoria, Ill.	16	(2)	(1)	22.9	25
Havana, Ill.	14	(2)	(1)	19.7	26–28
Beardstown, Ill.	12	(2)	(1)	21.3	27
Pearl, Ill.	12	(2)	(1)	19.1	27
Yazoo:					
Yazoo City, Miss.	25	2	(1)	30.8	27–30
Tallahatchie:					
Swan Lake, Miss.	25	16	(1)	28.7	30

[1] Continued into May. [2] March. [3] Continued from March

Flood stages for the month of April, 1920—Continued.

River and station.	Flood stage.	Above flood stages—dates. From—	To—	Crest. Stage.	Date.
MISSISSIPPI DRAINAGE—continued.					
Ouachita:	*Feet.*			*Feet.*	
Arkadelphia, Ark.	18	27	27	19.9	27
Camden, Ark.	30	(3)	3	33.8	[2] 31
Do.	30	29	(1)	35.1	30
Atchafalaya:					
Simmesport, La.	41	15	(1)	44.8	30
Melville, La.	37	8	(1)	41.6	30
Missouri:					
St. Charles, Mo.	25	9	10	25.2	10
Blairs, Nebr.	16	4	5	16.9	5
Pierre, S. Dak.	13	1	1	13.1	1
Grand:					
Chillicothe, Mo.	18	(3)	1	26.9	[2] 30
Do.	18	13	13	18.7	13
Do.	18	19	26	25.8	23
Brunswick, Mo.	10	(3)	10	11.6	8
Do.	10	20	27	10.8	21–25
Do.	10	30	(1)	10.3	30
James:					
Huron, S. Dak.	9	(3)	8	15.6	[2] 28
Petit Jean:					
Danville, Ark.	20	27	29	21.8	28
White:					
Newport, Ark.	26	(3)	1	29.3	[2] 29
Georgetown, Ark.	22	(3)	11	25.5	2
Black:					
Black Rock, Ark.	14	(3)	12	20.9	[2] 27
Sulphur:					
Finley, Tex.	24	(3)	2	28.0	[2] 29–30
Ringo Crossing, Tex.	20	27	29	21.2	27
WEST GULF DRAINAGE.					
Trinity:					
Trinidad, Tex.	28	(3)	6	36.7	2

[1] Continued into May. [2] March. [3] Continued from March.

MEAN LAKE LEVELS DURING APRIL, 1920.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., May 5, 1920.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.[1] Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during April, 1920:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.26	580.54	571.64	245.55
Above or below—				
Mean stage of March, 1920	+0.34	+0.54	+0.79	+0.50
Mean stage of April, 1919	+0.26	−0.49	−1.41	−0.88
Average stage for April, last 10 years	+0.62	+0.26	−0.76	−0.81
Highest recorded April stage	−0.43	−2.69	−2.54	−2.88
Lowest recorded April stage	+1.72	+1.32	+0.38	+0.71
Average relation of the April level to—				
March level	.....	+0.3	+0.6	+0.7
May level	.....	−0.3	−0.3	−0.3

[1] Lake St. Clair's level: In April, 574.80 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, APRIL, 1920.

By J. WARREN SMITH, Meteorologist in Charge.

The weather during April was, on the whole, unfavorable for the growth of vegetation and for farm operations in nearly all sections of the country. Cool weather for the season persisted throughout the month in most central and northern districts, and rainfall was frequent in many sections, particularly between the Mississippi River and Appalachian Mountains and in the Southeast, resulting in soil conditions unfavorable for spring planting.

During the first decade of the month heavy rains fell from the lower Mississippi Valley eastward, and the planting of corn and cotton was further retarded in that area, owing to the continued saturated condition of the soil; these crops germinated rather poorly in Texas, necessitating considerable replanting. Winter wheat made some improvement, but it was too cool for best results, and the unfavorable weather in the spring-wheat belt caused considerable delay in the preparation of soil for seeding, although some seeding was done in the southern portion of the belt. The cold, stormy weather in the northwestern districts during the first decade of the month was very unfavorable for stock.

During the second decade, continued cool weather and saturated soil were unfavorable for farm operations in all central and northern districts, and also in most southern sections, and at the same time drought prevailed in the lower and west-central Great Plains. This period was too cool for cotton and corn and too wet in most sections, but winter wheat made fair advance in many districts, particularly in the Plains region. It continued unfavorable for seeding spring wheat, and that work was considerably delayed.

During the last decade of the month, the higher temperatures that prevailed in the Southern States were more favorable, and corn showed considerable improvement in germination and growth, while cotton planting made better advance than previously. Winter grains showed general, though mostly slow, advance during this period, although the improvement was substantial in the central Great Plains area. The weather continued cloudy, rainy, and cold in the spring-wheat belt and little progress in seeding could be made. The latter part of the month was more favorable for potatoes and truck crops in the southern States, but the planting of truck and gardens was delayed in central and northern districts on account of low temperatures and wet soil.

CLIMATOLOGICAL TABLES.*

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, April, 1920.

Section.	Temperature.								Precipitation.					
			Monthly extremes.								Greatest monthly.		Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Section average.	Departure from the normal.	Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	62.3	− 0.8	2 stations	91	17†	St. Bernard	25	6	9.21	+ 5.00	St. Bernard	13.38	Uniontown	4.46
Arizona	55.2	− 3.8	2 stations	98	29†	Heber	5	1	0.25	− 0.22	Williams	1.68	27 stations	0.00
Arkansas	59.8	− 1.4	Bee Branch	94	22	Nail	11	5	5.49	+ 0.89	Helena	10.56	Hardy	1.42
California	54.8	− 2.2	Blythe	105	28	Portola	9	10	2.56	+ 0.77	Wrights	16.55	14 stations	0.00
Colorado	35.2	− 7.4	Lamar	90	10	Glendevey	−27	4	3.00	+ 1.13	Silver Lake	11.60	Dove Creek	0.35
Florida	70.9	+ 0.9	Arcadia	95	26	Quincy	30	6	6.26	+ 4.01	Wausau	11.6	Satsuma Heights	2.97
Georgia	62.7	− 0.4	2 stations	91	21†	Blue Ridge	22	6	7.29	+ 3.73	Blue Ridge	12.10	Carlton	3.09
Hawaii (March)	69.0	+ 0.5	2 stations	89	4†	Volcano Observatory	44	2	11.86	+ 3.78	Waiakamoi	56.16	Waiawa	0.00
Idaho	40.3	− 4.6	2 stations	78	26	Stanley	−18	2	1.97	+ 0.52	Wrensted Ranch	4.94	Mackay	0.13
Illinois	47.3	− 4.7	9 stations	80	1†	Joliet	8	6	4.41	+ 1.16	Tiskilwa	8.32	Pana	1.81
Indiana	47.0	− 5.1	Greencastle	85	22	3 stations	9	6	5.90	+ 2.52	Salamonia	10.35	Mt. Vernon	2.27
Iowa	42.4	− 6.3	3 stations	78	21	2 stations	2	5	4.59	+ 1.73	Oakland	7.23	Forest City	1.93
Kansas	49.0	− 4.8	2 stations	89	17	Centralia	0	5	2.78	+ 0.33	Wheaton	5.78	Anthony	0.61
Kentucky	50.8	− 5.1	Williamsburg	89	18	Scott	22	13	6.16	+ 2.22	Junction City	9.35	Jackson	3.40
Louisiana	66.7	− 0.3	St. Francisville	95	16	Calhoun	26	5	4.67	+ 0.26	Monroe	11.74	Merryville	0.83
Maryland-Delaware	51.1	− 1.3	Cumberland, Md.	88	22†	Oakland, Md.	12	9	4.62	+ 1.21	Oakland, Md.	6.99	Crisfield, Md.	2.55
Michigan	37.4	− 4.9	2 stations	79	1†	Bergland	− 3	5	2.96	+ 0.65	Wasepi	6.03	Cadillac	1.10
Minnesota	35.5	− 7.3	Pipestone	74	1	Hallock	−13	2	1.76	− 0.33	Grand Meadow	4.58	International Falls	0.10
Mississippi	63.4	− 0.8	Moorhead	92	18	3 stations	28	5	9.48	+ 4.39	Corinth	15.50	Woodville	3.71
Missouri	50.2	− 4.7	2 stations	89	18†	Edgerton	4	5	3.95	+ 0.15	Kidder	8.19	Fulton	1.41
Montana	36.4	− 6.2	Libby	73	26	Outlook	−10	5	1.93	+ 0.94	Cascade	5.14	Deer Lodge	0.47
Nebraska	40.4	− 8.4	Auburn	82	1	2 stations	− 7	4	5.03	+ 2.55	Burwell	10.27	Hershey	1.80
Nevada	47.4	− 3.3	Las Vegas	94	29	Tecoma	3	3	1.00	+ 0.26	Lamoille	4.82	3 stations	0.00
New England	41.1	− 2.0	Vernon, Vt.	80	20	Garfield, Vt.	2	9	5.71	+ 2.58	Bar Harbor, Me.	11.05	Houlton, Me.	2.50
New Jersey	48.0	− 1.0	Bridgeton	85	23	Culvers Lake	10	9	4.50	+ 0.93	Long Branch	6.06	Cape May	2.90
New Mexico	46.7	− 4.3	Artesia	93	29	Red River Canyon	− 6	4	0.61	− 0.67	Anchor Mine	3.54	12 stations	0.00
New York	41.9	− 2.1	2 stations	77	1†	Raquette Lake	− 2	9	3.77	+ 0.88	Medford	6.50	Fishs Eddy	1.24
North Carolina	56.7	− 0.6	2 stations	93	21†	Banners Elk	13	6	5.54	+ 2.06	Highlands	13.73	Sloan	2.73
North Dakota	32.1	− 9.8	2 stations	63	13†	4 stations	−11	3†	0.83	− 0.55	Hettinger	2.39	Pembina	0.10
Ohio	45.8	− 4.1	Ironton	90	22	2 stations	14	6	5.78	+ 2.58	Bellefontaine	9.06	Cadiz	3.29
Oklahoma	57.1	− 2.7	Pauls Valley	97	17	Hurley	4	9	2.52	− 0.83	Broken Bow	5.87	Mutual	0.53
Oregon	44.9	− 3.4	Grants Pass	85	26	2 stations	8	22†	3.53	+ 1.29	Headworks	12.38	Hay Creek	0.20
Pennsylvania	46.0	− 2.8	Lewisburg	87	22	Ebensburg	8	10	4.39	+ 0.96	Freeland	11.34	Towanda	2.44
Porto Rico	76.3	+ 0.9	Canóvanas	98	12	2 stations	54	6†	1.10	− 3.79	Lares	4.47	4 stations	0.00
South Carolina	61.1	− 0.9	Florence	94	22	Landrum	26	6	5.13	+ 2.21	Liberty	13.40	Ferguson	2.77
South Dakota	36.9	− 8.8	Menno	75	1	2 stations	− 8	4	3.44	+ 1.36	Custer	8.45	Meadow	1.22
Tennessee	57.0	− 1.5	Kenton	91	18	2 stations	20	14	8.16	+ 3.55	Hohenwald	17.42	Greenville (near)	3.65
Texas	65.0	− 1.1	2 stations	110	17	2 stations	9	4	1.05	− 2.17	Paris	5.26	12 stations	0.00
Utah	41.2	− 5.6	St. George	86	29	Blacks Fork	−10	23	2.08	+ 0.83	Great Basin Experiment Sta.	11.70	Hanksville	0.00
Virginia	53.6	− 1.1	Runnymede	96	21	Burkes Garden	17	6	3.84	+ 0.60	Newport News	6.36	Lassiter	1.66
Washington	44.8	− 3.8	Mottinger	95	25	Republic	9	3	3.04	+ 1.01	Cedar Lake	14.15	Trinidad	T.
West Virginia	49.7	− 2.0	Huntington	91	22	Bayard	15	6	4.91	+ 1.42	Pickens	7.26	Union	1.64
Wisconsin	37.9	− 5.7	Prairie du Chien	75	21	Ashland	− 5	4†	2.41	+ 0.01	Darlington	4.20	Rest Lake	0.67
Wyoming	33.2	− 8.5	Spencer	71	14	Lake Yellowstone	−29	1	2.55	+ 1.26	Chugwater	7.07	Powell	0.06

* For description of tables and charts, see this REVIEW, January, 1920, p. 54.

†Other dates also.

TABLE I.—*Climatological data for Weather Bureau stations, April, 1920.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 inch, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F*		° *F*	° *F*		° *F*	° *F*		° *F*	° *F*	%	*In.*	*In.*		*Miles*							*0–10*	*In.*	*In.*
New England.							**42.7**	**− 1.3**											**73**	**5.33**	**+ 2.3**									**6.7**		
Eastport	76	67	85	29.69	29.78	− .15	37.8	− 0.5	62	20	44	23	1	32	25	34	29	74	4.21	+ 1.3	14	9,427	w.	49	e.	28	5	7	18	7.1	13.7	0.0
Greenville, Me	1,070	6	....	28.61	29.79	.....	36.0	.....	63	20	44	16	1	28	33	....	....	....	....	5.40	.....	14	....	....	....	....	....	6	4	20	....	8.7	0.0
Portland, Me	103	82	117	29.69	29.82	− .14	41.2	− 1.8	69	20	48	24	9	35	26	37	31	70	7.04	+ 3.9	14	7,750	nw.	36	w.	6	7	7	16	6.6	0.3	0.0
Concord	288	70	79	29.50	29.82	− .17	41.4	− 2.4	72	20	50	21	9	33	38	....	....	....	....	5.91	+ 3.1	12	4,135	nw.	30	nw.	6	5	14	11	6.4	2.6	0.0
Burlington	404	11	48	29.35	29.80	− .19	40.0	− 0.7	64	20	47	22	9	33	32	....	....	....	....	5.83	+ 4.0	17	7,592	n.	40	s.	23	5	7	18	7.1	1.4	0.0
Northfield	876	12	60	28.85	29.81	− .20	37.2	− 3.0	67	20	46	17	8	28	41	34	28	71	5.12	+ 3.0	15	6,233	s.	36	sw.	3	5	3	22	7.6	4.1	0.0
Boston	125	115	188	29.67	29.81	− .16	45.0	− 0.3	67	20	52	26	9	38	30	41	35	69	5.68	+ 2.1	11	8,784	w.	41	w.	6	4	12	14	6.7	2.0	0.0
Nantucket	12	14	90	29.79	29.80	− .17	43.1	− 1.1	60	20	48	28	9	38	18	41	38	85	3.86	+ 1.2	16	13,146	sw.	49	se.	23	8	8	14	6.4	0.1	0.0
Block Island	26	11	46	29.77	29.80	− .18	43.4	− 0.4	62	20	49	30	10	38	25	40	39	88	5.24	+ 1.6	15	14,067	sw.	50	w.	6	11	3	16	6.1	0.2	0.0
Providence	160	215	251	29.63	29.81	− .17	45.0	− 1.6	71	20	53	26	9	37	30	39	33	67	4.70	+ 0.9	15	11,016	nw.	54	nw.	24	5	11	14	6.6	T.	0.0
Hartford	159	122	140	29.64	29.82	− .17	44.8	− 1.9	70	20	53	24	9	37	27	39	32	64	5.43	+ 1.9	14	6,240	n.	37	w.	29	4	10	16	6.9	0.1	0.0
New Haven	106	74	153	29.71	29.82	− .17	45.4	− 1.0	67	30	53	26	9	38	25	40	33	66	5.62	+ 2.1	15	8,214	n.	39	nw.	24	10	7	13	5.8	T.	0.0
Middle Atlantic States.							**50.0**	**− 0.6**											**66**	**3.80**	**+ 0.7**									**5.8**		
Albany	97	102	115	29.71	29.82	− .18	44.4	− 1.4	69	20	53	25	9	36	33	39	32	65	3.90	+ 1.5	11	5,850	nw.	29	nw.	24	10	8	12	5.7	1.1	0.0
Binghamton	871	10	84	28.87	29.81	− .21	43.6	− 0.8	71	1	52	20	8	35	38	....	....	....	....	2.43	+ 0.2	18	4,944	w.	24	nw.	24	4	9	17	7.4	0.7	0.0
New York	314	414	454	29.48	29.82	− .18	47.7	− 0.4	73	22	56	30	9	39	27	40	33	62	4.44	+ 1.1	14	14,487	nw.	66	nw.	24	5	14	11	6.3	T.	0.0
Harrisburg	374	94	104	29.45	29.85	− .17	48.2	− 2.5	81	22	56	28	10	40	27	41	34	61	4.37	+ 1.9	16	6,358	w.	31	w.	7	6	13	11	6.2	T.	0.0
Philadelphia	117	123	190	29.72	29.84	− .17	51.4	+ 0.6	80	23	60	32	9	42	28	44	37	65	3.92	+ 1.0	16	8,133	nw.	35	nw.	23	10	13	7	5.3	T.	0.0
Reading	325	81	98	29.48	29.84	.....	48.8	.....	80	22	58	27	10	40	29	42	35	64	5.10	+ 1.9	17	6,383	nw.	31	nw.	7	6	11	13	6.4	T.	0.0
Scranton	805	111	119	28.97	29.84	− .17	45.4	− 1.7	73	22	54	23	8	36	33	40	35	74	2.53	− 0.1	16	6,499	sw.	33	sw.	6	6	7	17	6.7	0.4	0.0
Atlantic City	52	37	48	29.78	29.84	− .16	48.1	+ 0.5	80	22	55	32	6	41	31	43	38	72	3.39	+ 0.4	15	6,545	nw.	33	s.	2	11	11	8	4.9	T.	0.0
Cape May	18	13	49	29.85	29.87	− .12	49.7	+ 1.3	78	22	57	31	9	43	28	44	39	72	2.90	− 0.1	11	7,540	nw.	36	s.	13	14	8	8	4.6	T.	0.0
Sandy Hook	22	10	57	29.80	29.82	.....	46.5	.....	71	22	53	29	8	40	25	42	38	78	4.96	.....	15	12,404	sw.	63	nw.	23	6	14	10	5.9	T.	0.0
Trenton	190	159	183	29.62	29.82	.....	47.8	.....	78	22	57	28	9	39	27	42	35	64	4.34	+ 1.0	15	10,368	w.	44	w.	6	8	12	10	6.1	T.	0.0
Baltimore	123	100	113	29.72	29.85	− .16	52.8	+ 0.2	82	22	61	32	6	44	30	45	37	61	4.84	+ 1.6	14	5,736	sw.	27	sw.	7	8	11	11	5.9	T.	0.0
Washington	112	62	85	29.72	29.84	− .18	52.6	− 0.5	84	22	62	31	6	44	32	45	37	61	4.69	+ 1.4	18	6,465	nw.	34	nw.	7	9	9	12	5.8	T.	0.0
Lynchburg	681	153	188	29.12	29.86	− .16	54.3	− 1.3	85	22	65	29	6	43	39	47	41	65	3.53	+ 0.4	11	7,006	nw.	40	sw.	5	15	7	8	4.9	T.	0.0
Norfolk	91	170	205	29.78	29.88	− .13	57.3	+ 1.3	85	23	66	34	6	48	32	49	42	63	4.25	+ 0.5	13	11,223	s.	62	w.	7	11	9	10	5.2	0.0	0.0
Richmond	144	11	52	29.71	29.86	− .16	55.2	− 2.0	86	23	66	31	14	45	33	49	44	69	2.96	− 0.5	13	6,927	s.	49	sw.	30	10	6	14	5.9	0.0	0.0
Wytheville	2,304	49	56	27.49	29.86	− .17	49.6	− 2.4	81	22	60	22	6	39	38	43	36	65	3.23	− 0.4	15	6,348	w.	40	w.	23	13	9	8	4.7	1.4	0.0
South Atlantic States.							**61.1**	**− 0.1**											**73**	**4.89**	**+ 1.6**									**5.3**		
Asheville	2,255	70	84	27.54	29.89	− .14	52.9	− 1.0	81	22	64	25	6	42	39	45	39	66	5.43	+ 1.4	17	8,482	nw.	38	s.	12	14	8	8	4.7	T.	0.0
Charlotte	779	55	62	29.04	29.88	− .15	57.8	− 1.4	86	22	68	30	6	48	31	51	45	67	5.40	+ 2.0	13	5,313	sw.	38	nw.	2	15	4	11	4.9	0.0	0.0
Hatteras	11	12	50	29.87	29.88	− .13	58.0	0.0	77	22	64	40	6	52	24	53	52	82	4.46	+ 0.1	13	11,909	sw.	50	ne.	10	12	7	11	5.4	0.0	0.0
Manteo	12	5	42	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Raleigh	376	103	110	29.47	29.88	− .15	57.8	− 1.2	87	22	68	30	6	47	33	52	46	69	3.40	− 0.1	13	7,566	sw.	39	w.	5	12	7	11	5.3	0.0	0.0
Wilmington	78	81	91	29.82	29.90	− .13	61.6	+ 1.2	88	22	70	36	6	54	31	57	54	81	4.69	+ 1.8	16	7,493	sw.	37	sw.	5	12	8	10	5.0	0.0	0.0
Charleston	48	11	92	29.85	29.90	− .13	64.0	+ 0.2	84	17	72	36	6	56	27	58	54	76	7.40	+ 4.4	12	9,059	s.	36	s.	5	10	5	15	6.3	0.0	0.0
Columbia, S. C	351	41	57	29.52	29.90	− .13	61.9	− 0.9	87	21	72	32	6	52	30	54	48	68	3.41	+ 0.6	10	6,326	sw.	32	w.	5	11	5	14	5.7	0.0	0.0
Greenville, S. C	1,039	113	122	28.77	29.86	.....	57.3	.....	86	17	67	29	6	48	32	50	44	68	7.18	.....	11	7,949	sw.	60	w.	20	13	5	12	5.1	0.0	0.0
Augusta	180	62	77	29.69	29.88	− .15	63.4	+ 0.2	86	21	73	34	6	54	32	57	52	72	4.94	+ 1.4	19	5,386	s.	29	sw.	5	11	5	14	5.7	0.0	0.0
Savannah	65	150	194	29.84	29.92	− .11	65.0	+ 0.3	86	17	73	38	6	57	26	59	55	75	6.35	+ 3.4	12	10,018	s.	49	w.	5	10	4	16	5.9	0.0	0.0
Jacksonville	43	209	245	29.88	29.93	− .13	68.8	+ 1.2	88	20	77	45	6	61	25	62	58	76	3.42	+ 0.7	8	9,639	sw.	45	s.	27	14	7	9	4.6	0.0	0.0
Florida Peninsula.							**74.7**	**+ 1.2**											**80**	**4.85**	**+ 3.0**									**5.1**		
Key West	22	10	64	29.92	29.94	− .08	77.2	+ 1.7	87	29	82	61	6	72	16	72	70	81	3.36	+ 2.1	5	8,166	se.	49	nw.	9	15	6	9	4.3	0.0	0.0
Miami	25	71	79	29.94	29.97	.....	75.0	+ 1.1	87	28	81	48	6	69	28	70	68	79	3.15	+ 0.6	7	6,470	se.	30	nw.	9	7	13	10	5.8	0.0	0.0
Sand Key	23	39	72	29.89	29.92	− .10	75.3	.....	84	23	78	61	6	73	15	72	70	83	5.39	.....	7	9,634	se.	52	nw.	5	14	9	7	4.1	0.0	0.0
Tampa	35	79	92	29.91	29.94	− .12	71.9	+ 0.9	87	26	79	46	6	64	28	66	63	79	8.04	+ 6.2	7	5,259	sw.	34	sw.	5	5	12	13	6.1	0.0	0.0
East Gulf States.							**63.7**	**− 0.7**											**72**	**8.12**	**+ 4.0**									**5.9**		
Atlanta	1,174	190	216	28.66	29.89	− .14	58.6	− 2.5	84	17	68	30	14	50	30	52	46	68	5.32	+ 1.7	15	9,321	nw.	44	nw.	5	9	6	15	5.9	T.	0.0
Leesburg	279	10	55	29.62	29.93	.....	64.4	.....	87	21	74	35	6	55	30	59	55	75	9.67	.....	11	6,298	s.	37	s.	27	7	8	15	6.6	0.0	0.0
Macon	370	78	87	29.50	29.90	− .13	62.9	− 0.2	87	21	72	34	6	53	34	56	50	69	6.06	+ 2.7	10	5,220	s.	33	s.	16	9	5	16	6.3	0.0	0.0
Thomasville	273	49	58	29.62	29.91	− .12	66.4	− 0.3	87	25	75	37	6	57	30	60	56	74	7.22	+ 3.6	11	3,954	sw.	25	sw.	20	6	7	17	6.8	0.0	0.0
Pensacola	56	149	185	29.83	29.89	− .13	65.8	− 1.9	80	2	71	39	5	60	24	61	58	79	8.63	+ 5.5	8	11,443	se.	60	n.	12	8	9	13	6.4	0.0	0.0
Anniston	741	9	57	29.10	29.90	− .13	59.5	− 0.9	87	17	71	28	14	48	38	....	....	....	8.77	+ 5.1	14	5,514	nw.	33	sw.	6	11	11	8	4.9	T.	0.0
Birmingham	700	11	48	29.14	29.90	− .12	61.2	− 2.3	87	17	72	33	5	51	37	53	47	65	10.71	+ 7.0	16	6,479	s.	37	s.	1	10	12	8	5.1	T.	0.0
Mobile	57	125	161	29.82	29.88	− .14	66.4	+ 0.4	85	4	74	38	5	59	34	61	57	78	5.89	+ 1.5	10	9,085	s.	39	nw.	5	6	12	12	5.7	0.0	0.0
Montgomery	223	100	112	29.64	29.90	− .13	64.0	+ 1.2	85	17	73	37	6	55	33	58	53	71	9.31	+ 5.1	13	6,009	se.	31	sw.	6	8	9	13	6.0	0.0	0.0
Corinth	469	6	....	....	....	....	60.2	.....	91	17	72	30	5	49	37	....	....	....	15.50	.....	13	....	se.	....	....	....	....	....	9	12	9	....	0.0	0.0
Meridian	375	85	93	29.47	29.86	− .16	62.8	− 1.3	88	17	73	34	5	53	38	57	51	67	9.43	+ 4.4	11	5,303	s.	28	se.	20	10	11	9	5.5	0.0	0.0
Vicksburg	247	65	74	29.58	29.86	− .14	64.0	− 1.2	88	18	73	35	5	55	31	56	51	67	10.15	+ 5.0	9	6,633	se.	40	nw.	8	8	13	9	5.2	0.0	0.0
New Orleans	53	76	84	29.81	29.86	− .14	69.1	+ 1.2	87	17	76	42	5	62	26	64	62	84	7.84	+ 2.9	6	6,155	s.	27	nw.	4	8	10	12	5.9	0.0	0.0
West Gulf States.							**64.5**	**− 1.3**											**66**	**2.07**	**− 1.5**									**4.6**		
Shreveport	249	77	93	29.55	29.82	− .15	64.4	− 1.4	92	16	75	31	5	54	31	55	48	62	4.01	− 0.6	8	7,240	se.	42	nw.	11	17	5	8	3.8	0.0	0.0
Bentonville	1,303	11	44	28.41	29.78	− .18	54.4	− 2.5	85	18	66	19	5	43	38	....	....	....	2.54	− 1.4	11	5,768	s.	32	s.	15	14	7	9	4.8	1.0	0.0
Fort Smith	457	79	94	29.31	29.79	− .17	58.8	− 1.9	88	17	69	27	5	48	36	51	45	66	3.40	− 0.5	7	8,152	e.	44	w.	12	12	9	9	4.8	T.	0.0
Little Rock	357	139	147	29.43	29.81	− .17	60.2	− 2.5	85	21	70	28	5	51	31	52	45	64	6.59	+ 2.1	10	8,107	s.	42	w.	1	12	8	10	4.9	T.	0.0
Brownsville	57	4	26	....	....	....	75.8	....	....	....	....	....	....	....	....	....	....	....	0.06	....	....	....	se.	....	....	....	....	....	....	....	....	....	....
Corpus Christi	20	69	77	29.79	29.81	− .14	70.8	− 0.1	95	18	77	49	4	64	27	64	60	75	0.11	− 1.7	3	9,983	se.	47	s.	6	11	7	12	5.9	0.0	0.0
Dallas	512	109	117	29.26	29.80	.....	63.8	.....	92	17	76	32	5	52	40	....	....	....	2.12	.....	4	9 243	s.	42	nw.	3	14	12	4	3.8	0.0	0.0
Fort Worth	670	106	114	29.06	29.76	− .18	63.6	− 1.7	92	17	76	31	4	51	40	53	43	55	0.51	− 2.1	4	10,076	nw.	46	nw.	4	14	10	6	3.8	0.0	0.0
Galveston	54	106	114	29.79	29.84	− .13	67.3	− 1.4	82	20	72	41	5	62	19	62	59	78	0.70	− 2.4	4	9,763	se.	38	nw.	26	12	11	7	4.8	0.0	0.0
Groesbeck	461	11	56	29.30	29.78	.....	65.3	.....	93	16	78	28	5	53	37	55	48	61	2.01	.....	4	10,875	s.	52	sw.	6	17	6	7	3.6	0.0	0.0
Houston	138	111	121	29.68	29.83	.....	68.2	− 1.4	92	16	78	38	5	58	28	....	....	....	0.39	.....	4	7,474	se.	33	nw.	4	10	8	12	5.4	0.0	0.0
Palestine	510	64	72	29.29	29.82	− .14	64.8	− 1.1	91	16	76	32	5	54	35	55	48	63	1.16	− 2.9	7	7,279	s.	29	sw.	6	14	6	10	4.4	0.0	0.0
Port Arthur	34	58	66	29.78	29.82	.....	67.2	.....	84	16	74	36	5	60	23	61	57	75	0.97	.....	5	8,859	s.	36	sw.	6	12	9	9	5.5	0.0	0.0
San Antonio	701	119	132	29.08	29.80	− .13	69.4	+ 0.4	100	17	82	37	5	57	37	57	48	57	1.09	− 1.8	4	6,896	se.	39	nw.	3	15	9	6	4.0	0.0	0.0
Taylor	582	55	63	29.23	29.84	− .11	67.1	− 0.4	94	17	80	31	5	54	39	....	....	....	0.60	− 3.4	4	8,497	s.	36	s.	6	18	6	6	3.8	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, April, 1920*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01, inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.							
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	*F*		° *F*	° *F*		° *F*	° *F*	° *F*	° *F*	° *F*	%	*In.*	*In.*		*Miles*									*0–10*	*In.*	*In.*
							51.2	**− 3.4**											**69**	**6.21**	**+ 2.6**										**6.7**		
Chattanooga	762	189	213	29.09	29.90	− .13	58.0	− 2.0	85	22	68	30	5	48	36	49	42	62	9.83	+ 5.4	14	7,703	sw.	50	sw.	6	11	9	10	5.5	0.1	0.0
Knoxville	996	102	111	28.81	29.86	− .17	57.0	− 0.4	87	18	68	30	14	46	35	48	40	58	7.22	+ 2.6	14	6,527	sw.	45	sw.	6	9	11	10	5.7	T.	0.0
Memphis	399	76	97	29.45	29.87	− .13	59.4	− 2.4	86	18	68	29	5	51	35	53	49	72	7.75	+ 2.9	10	8,265	sw.	44	sw.	4	12	10	8	4.9	T.	0.0
Nashville	546	168	191	29.28	29.87	− .14	56.2	− 2.9	85	22	66	28	5	46	39	49	42	64	8.58	+ 4.2	12	9,390	s.	52	se.	1	9	11	10	5.3	T.	0.0
Lexington	989	193	230	28.78	29.85	− .17	49.7	− 4.0	82	22	59	26	5	41	35	.....	.....	.....	6.42	+ 3.1	14	12,852	sw.	60	sw.	6	7	6	17	6.8	0.1	0.0
Louisville	525	219	255	29.27	29.86	− .15	51.2	− 5.0	82	22	60	26	13	42	35	46	41	72	5.16	+ 1.1	11	11,260	s.	52	sw.	4	5	11	14	6.4	T.	0.0
Evansville	431	139	175	29.37	29.84	− .16	52.8	− 3.6	79	21	62	26	5	43	34	46	41	69	2.93	− 0.5	12	10,938	sw.	53	sw.	15	3	13	14	6.6	T.	0.0
Indianapolis	822	194	230	28.93	29.82	− .18	46.8	− 5.6	77	20	55	23	13	38	28	41	36	71	7.26	+ 3.8	19	11,235	w.	47	s.	1	3	10	17	7.4	2.9	0.0
Royal Center	736	11	55	29.02	29.83	.....	43.3	.....	74	22	52	16	6	35	27	39	34	73	5.56	.....	20	11,078	w.	52	sw.	2	3	11	16	7.2	4.8	0.0
Terre Haute	575	96	129	29.18	29.80	.....	48.3	.....	74	22	57	24	5	40	29	44	41	79	4.65	.....	14	9,308	sw.	42	n.	12	3	14	13	7.2	3.6	0.0
Cincinnati	628	11	51	29.16	29.84	− .17	48.0	− 4.3	81	22	57	22	13	39	37	44	39	71	5.78	+ 2.8	20	7,996	sw.	44	sw.	12	5	8	17	6.8	5.2	0.0
Columbus	824	179	222	28.96	29.84	− .18	46.0	− 5.0	81	22	54	21	13	38	34	42	38	76	4.51	+ 1.6	20	10,398	w.	65	w.	2	0	11	19	7.9	5.4	0.0
Dayton	899	181	216	28.84	29.80	.....	46.9	− 4.8	80	22	55	22	13	39	28	42	36	70	5.28	+ 2.4	21	10,152	sw.	44	nw.	7	3	10	17	7.1	4.3	0.0
Elkins	1,947	59	67	27.79	29.85	− .19	47.2	− 1.5	82	22	58	20	10	36	44	41	36	70	5.45	+ 2.2	18	5,737	w.	37	nw.	2	5	5	20	7.4	3.7	0.0
Parkersburg	638	77	84	29.20	29.86	− .17	50.6	− 2.4	85	22	60	26	6	42	36	43	36	62	6.38	+ 3.5	18	6,030	sw.	54	sw.	4	5	8	17	6.9	T.	0.0
Pittsburgh	842	353	410	28.92	29.83	− .19	47.0	− 4.0	81	22	56	22	6	38	32	41	35	66	4.42	+ 1.5	20	10,330	sw.	53	sw.	12	2	6	22	8.4	1.5	0.0
Lower Lake Region.							**41.7**	**− 3.4**											**72**	**3.55**	**+ 1.2**										**7.3**		
Buffalo	767	247	280	28.97	29.81	− .20	39.8	− 2.5	70	22	48	19	8	32	35	35	31	74	2.33	− 0.1	13	13,645	w.	60	w.	2	5	6	19	7.3	1.7	0.0
Canton	448	10	61	29.29	29.77	.....	40.2	− 2.3	66	20	48	20	9	32	32	.....	.....	.....	3.45	+ 1.2	16	8,914	w.	52	w.	3	6	7	17	6.9	5.1	0.0
Oswego	335	76	91	29.43	29.80	− .21	40.0	− 3.2	70	1	46	23	9	34	30	37	33	77	2.56	+ 0.3	16	8,422	w.	34	nw.	7	7	10	13	6.4	7.5	0.0
Rochester	523	86	102	29.24	29.82	− .19	42.2	− 1.7	75	1	51	20	8	34	38	37	31	68	2.55	+ 0.1	19	7,819	w.	50	w.	2	4	9	17	7.2	2.2	0.0
Syracuse	597	97	113	29.17	29.82	− .19	42.5	− 1.9	73	1	50	19	8	5	30	.....	.....	.....	3.19	+ 0.9	17	9,234	w.	46	w.	3	3	11	16	6.9	3.0	0.0
Erie	714	130	166	29.03	29.80	− .22	42.4	− 2.3	79	22	50	22	8	35	34	38	34	71	3.09	+ 0.7	18	12,208	w.	54	w.	2	2	13	15	6.8	2.2	0.0
Cleveland	762	190	201	28.99	29.82	− .20	42.6	− 3.4	77	22	49	23	6	36	26	38	34	73	5.01	+ 2.7	19	11,354	ne.	48	w.	22	2	10	18	8.0	2.9	0.0
Sandusky	629	62	103	29.12	29.81	− .21	42.8	− 4.5	80	22	49	22	6	37	29	.....	.....	.....	4.77	+ 2.2	18	11,385	sw.	58	sw.	2	1	12	17	7.8	1.8	0.0
Toledo	628	208	243	29.14	29.82	− .19	42.4	− 4.9	76	22	50	21	6	35	28	38	34	73	5.14	+ 2.9	16	12,618	sw.	62	sw.	22	4	6	20	7.5	6.1	0.0
Fort Wayne	856	113	124	28.90	29.83	.....	43.0	− 6.3	77	22	51	20	5	35	27	38	33	69	4.68	.....	18	9,358	sw.	48	sw.	2	2	7	21	8.1	5.6	0.0
Detroit	730	218	245	29.02	29.82	− .20	41.0	− 4.5	70	22	48	19	6	34	27	37	33	75	3.38	+ 1.0	17	10,062	w.	54	w.	2	2	8	20	7.9	5.0	0.0
Upper Lake Region.							**36.9**	**− 3.8**											**74**	**2.60**	**+ 0.3**										**6.6**		
Alpena	609	13	92	29.13	29.81	− .21	35.0	− 3.0	55	1	41	13	6	29	27	32	28	75	2.42	+ 0.2	17	9,204	nw.	42	sw.	2	2	14	14	7.1	3.2	0.0
Escanaba	612	54	60	29.16	29.84	− .18	34.5	− 2.7	56	29	42	10	30	28	24	31	26	75	1.63	− 0.4	9	7,691	n.	40	n.	12	13	7	10	4.6	2.3	0.0
Grand Haven	632	54	89	29.12	29.81	− .20	39.0	− 5.0	70	22	46	21	4	32	32	36	32	77	2.29	− 0.2	14	9,825	w.	49	sw.	2	4	10	16	7.2	5.6	0.0
Grand Rapids	707	70	87	29.04	29.82	− .20	41.1	− 5.1	72	22	49	18	5	33	29	36	30	68	2.95	+ 0.5	12	5,714	w.	28	w.	2	4	7	19	7.0	6.5	0.0
Houghton	684	62	99	29.10	29.84	− .18	33.1	− 3.8	56	25	40	11	3	27	27	.....	.....	.....	2.81	+ 0.8	13	9,081	w.	42	w.	3	5	8	17	6.9	12.7	0.0
Lansing	878	11	62	28.86	29.81	.....	39.9	− 5.7	74	22	49	13	6	31	29	35	31	73	3.25	+ 0.7	18	6,093	w.	30	w.	2	2	6	22	7.9	11.5	0.0
Ludington	637	60	66	29.11	29.82	.....	37.6	.....	66	22	44	21	7	31	33	34	30	77	2.82	.....	14	8,649	n.	46	sw.	2	4	12	14	6.6	2.2	0.0
Marquette	734	77	111	29.05	29.87	− .15	32.9	− 4.6	56	25	39	11	3	27	33	30	27	80	2.28	+ 0.3	12	7,581	nw.	40	s.	2	4	6	20	7.6	4.2	0.0
Port Huron	638	70	120	29.11	29.81	− .21	39.1	− 3.1	68	22	46	18	9	32	27	36	32	79	2.36	+ 0.3	14	10,117	ne.	45	w.	3	4	11	15	6.7	7.4	0.0
Saginaw	641	69	77	29.10	29.81	.....	39.2	.....	70	22	47	17	6	32	29	35	30	70	2.55	− 0.1	16	7,893	ne.	42	sw.	2	5	6	19	7.2	6.3	0.0
Sault Ste. Marie	614	11	52	29.11	29.82	− .21	34.1	− 1.6	57	19	41	14	7	28	25	31	27	78	3.71	+ 1.6	16	7,786	nw.	37	nw.	5	9	6	15	6.3	3.0	0.0
Chicago	823	140	310	28.94	29.84	− .16	43.0	− 2.9	73	22	50	20	6	36	30	37	32	70	4.71	+ 1.8	16	10,723	ne.	48	sw.	2	6	10	14	6.4	6.4	0.0
Green Bay	617	109	144	29.14	29.81	− .20	37.6	− 3.1	62	29	45	13	3	30	29	33	27	68	2.11	− 0.3	9	9,516	n.	54	ne.	22	5	13	12	6.7	0.6	0.0
Milwaukee	681	125	139	29.08	29.82	− .17	39.4	− 2.4	65	1	46	20	5	33	34	35	30	73	1.92	− 0.8	15	8,398	ne.	44	sw.	2	5	9	16	6.8	2.1	0.0
Duluth	1,133	11	47	28.65	29.90	− .11	31.6	− 6.8	59	29	39	1	4	24	25	29	25	80	1.41	− 0.7	8	11,175	ne.	62	nw.	2	13	7	10	4.7	2.1	0.0
North Dakota.							**33.2**	**− 7.5**											**70**	**0.67**	**− 1.2**										**4.9**		
Moorhead	940	8	57	28.94	29.98	− .01	34.5	− 6.9	60	17	45	7	2	24	32	30	26	76	0.85	− 1.5	8	6,450	n.	35	nw.	2	17	5	8	4.0	2.7	0.0
Bismarck	1,674	8	57	28.19	30.02	+ .05	34.6	− 8.0	59	30	45	4		24	31	29	21	63	0.45	− 1.4	6	7,585	nw.	31	nw.	6	8	12	10	5.7	0.2	0.0
Devils Lake	1,482	11	44	28.37	29.99	.00	31.2	− 7.0	55	28	41	2	2	21	29	27	22	73	0.54	− 1.5	4	8,502	nw.	38	n.	1	14	9	7	4.4	1.0	0.0
Ellendale	1,457	10	56	28.37	29.96	.....	33.8	.....	57	30	44	4	4	23	29	30	23	68	1.48	.....	8	10,954	ne.	43	n.	22	7	8	15	6.3	3.5	0.0
Grand Forks	835	12	89	.....	.....	.....	32.4	.....	57	17	43	− 9	2	22	31	30	.....	.....	0.60	.....	4	.....	.....	.....	.....	.....	21	3	6	.....	1.2	0.0
Williston	1,878	41	48	27.96	29.99	+ .03	32.5	− 8.0	57	30	41	− 3	5	24	28	28	23	69	0.86	− 0.4	11	7,258	n.	38	se.	13	9	10	11	5.5	1.3	T.
Upper Mississippi Valley.							**44.8**	**− 5.7**											**70**	**3.86**	**+ 0.9**										**6.5**		
Minneapolis	918	102	208	28 87	29.86	.....	38.6	.....	69	21	47	9	4	30	27	.....	.....	.....	2.23	− 0.2	11	9,699	n.	41	w.	2	6	10	14	6.8	5.5	0.0
St. Paul	837	236	261	28.95	29.87	− .12	38.8	− 6.9	68	21	47	10	4	31	31	.....	.....	.....	2.21	− 0.1	12	10,409	nw.	54	w.	2	7	15	8	5.6	5.0	0.0
La Crosse	714	11	48	29.05	29.83	− .15	41.6	− 5.7	73	21	50	16	3	33	29	.....	.....	.....	3.45	+ 1.2	12	4,587	ne.	26	s.	21	8	5	17	6.9	2.3	0.0
Madison	974	70	78	28.78	29.84	− .15	40.4	− 4.1	70	21	48	19	5	33	34	35	29	67	3.43	+ 1.0	16	8,355	nw.	39	n.	12	6	8	16	7.0	0.6	0.0
Wausau	1,247	4	....	28 46	29.81	.....	36.6	.....	64	21	46	6	3	28	28	.....	.....	.....	1.82	.....	7	.....	n.	.....	.....	.....	5	9	16	.....	2.8	0.0
Charles City	1,015	10	49	28.76	29.85	− .20	40.3	− 6.0	71	21	49	15	5	32	25	36	31	72	3.31	+ 0.5	13	5,925	nw.	32	nw.	2	4	13	13	6.7	0.7	0.0
Davenport	606	71	79	29.17	29.83	− .15	44.0	− 6.2	74	21	52	18	5	36	29	39	34	73	5.04	+ 2.2	18	7,407	e.	34	nw.	2	7	7	16	6.9	1.0	0.0
Des Moines	861	84	97	28.91	29.83	− .14	43.9	− 6.7	72	21	52	18	5	36	30	39	33	69	4.09	+ 1.1	14	6,409	n.	30	e.	18	5	9	16	7.1	0.7	0.0
Dubuque	698	81	96	29.10	29.86	− .12	42.8	− 6.1	73	21	51	19	5	35	28	37	31	66	3.91	+ 1.0	16	6,065	nw.	30	e.	19	7	8	15	6.3	0.3	0.0
Keokuk	614	64	78	29.15	29.83	− .15	45.7	− 6.3	78	21	54	13	5	38	37	41	35	68	3.64	+ 0.3	15	7,412	ne.	44	sw.	22	4	10	16	6.9	8.6	0.0
Cairo	356	87	93	29.44	29.82	− .17	55.2	− 3.1	80	18	64	26	5	46	29	49	43	69	3.35	− 0.2	12	9,312	s.	53	sw.	4	7	10	13	6.2	T.	0.0
Peoria	609	11	45	29.16	29.83	− .16	44.2	− 6.7	75	1	53	14	5	36	33	40	37	78	6.12	+ 2.8	16	7,211	w.	39	w.	2	8	8	14	6.2	8.2	0.0
Springfield, Ill	644	10	91	29.13	29.81	− .17	46.7	− 5.3	77	21	55	17	5	38	29	42	38	75	5.42	+ 2.1	14	7,906	w.	38	se.	19	7	7	16	6.2	8.2	0.0
Hannibal	534	74	109	29.22	29.80	− .18	47.0	− 6.6	82	21	56	11	5	38	43	.....	.....	.....	4.36	+ 1.1	16	8,525	sw.	45	sw.	22	8	7	15	6.6	13.2	0.0
St. Louis	567	265	303	29.20	29.80	− .18	51.2	− 4.9	80	21	60	22	5	42	28	44	37	63	3.43	− 0.1	11	11,170	nw.	51	sw.	1	9	8	13	5.9	0.2	0.0
Missouri Valley.							**44.1**	**− 6.4**											**72**	**3.92**	**− 1.0**										**6.3**		
Columbia, Mo	781	11	84	28.94	29.78	− .20	48.8	− 5.5	82	21	58	14	5	39	43	.....	.....	.....	3.98	+ 0.3	13	8,271	w.	40	sw.	22	9	7	14	6.3	4.6	0.0
Kansas City	963	161	181	28.76	29.80	− .18	48.0	− 6.3	79	21	56	17	5	39	39	42	36	68	5.02	+ 1.7	14	10,894	e.	47	w.	22	8	11	11	5.7	7.0	0.0
St. Joseph	967	11	49	28.76	29.80	.....	47.0	.....	78	21	56	16	5	38	40	41	36	69	5.80	.....	13	8,582	nw.	52	w.	22	8	10	12	5.9	6.3	0.0
Springfield, Mo	1,324	98	104	28.39	29.80	− .17	51.6	− 4.1	83	18	62	16	5	41	42	45	39	69	1.53	− 2.3	14	9,890	se.	50	se.	25	15	7	8	4.1	2.0	0.0
Iola	984	11	50	28.71	29.75	− .20	52.1	− 2.1	82	21	64	18	15	41	37	.....	.....	.....	2.01	− 0.8	12	6,910	e.	31	w.	22	8	11	11	6.0	0.6	0.0
Topeka	987	92	107	.....	.....	.....	47.8	− 5.9	82	15	58	13	5	38	39	.....	.....	.....	4.44	+ 1.7	12	9,279	n.	44	n.	4	5	16	9	6.0	7.5	0.0
Drexel	1,299	10	53	28.42	29.82	.....	42.2	.....	70	21	51	17	5	34	30	38	33	75	4.65	.....	16	9,632	ne.	48	nw.	22	5	12	13	6.9	4.1	0.0
Lincoln	1,189	11	84	.....	29.83	− .11	44.0	− 6.7	75	21	53	15	5	35	38	.....	.....	.....	5.06	+ 2.3	12	9,036	n.	51	nw.	22	2	16	12	.....	9.0	0.0
Omaha	1,105	115	122	28.65	29.84	− .11	44.2	− 6.3	72	21	52	20	4	36	28	39	34	71	3.39	+ 0.4	14	7,755	nw.	40	nw.	1	5	12	13	7.1	5.6	0.0
Valentine	2,598	47	54	27.14	29.89	− .05	37.0	− 8.4	72	14	46	10	4	27	40	33	28	76	4.45	+ 2.1	13	7,839	n.	34	ne.	18	6	7	17	6.6	32.2	0.0
Sioux City	1,135	94	164	28.64	29.87	− .08	40.8	− 7.7	66	21	49	17	4	33	29	37	32	74	6.35	+ 3.6	17	9,556	n.	44	n.	1	3	12	15	7.1	3.2	0.0
Huron	1,306	59	74	28.52	29.94	− .02	36.9	− 7.7	60	28	46	11	4	28	28	33	26	67	3.05	+ 0.4	12	8,400	nw.	31	nw.	1	10	6	14	5.9	T.	0.0
Pierre	1,572	70	75	28.24	29.93	− .02	38.1	− 8.4	65	28	47	9	4	29	31	35	31	77	3.37	+ 1.4	11	7,612	ne.	35	nw.	22	8	5	17	6.6	7.9	0.0
Yankton	1,233	49	57	28.53	29.86	− .09	40.0	− 7.4	62	28	48	16	4	32	29	.....	.....	.....	4.34	+ 1.5	15	7,120	nw.	37	nw.	22	2	14	14	7.3	5.2	0.0

TABLE I.—*Climatological data for Weather Bureau stations, April, 1920*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	° *F.*	° *F.*	*°F*		*°F*	° *F*		*°F*	*°F*	° *F*	° *F*	° *F*	*%*	*In.*	*In.*		*Miles*							*0–10*	*In.*	*In.*
Northern Slope.							**35.7**	**− 6.9**											**71**	**2.74**	**+ 1.1**									**6.9**		
Billings	3,140	5																															
Havre	2,595	11	44	27.28	29.96	+ .03	36.0	− 6.7	65	19	45	9	4	27	36	32	28	78	2.65	+ 1.6	13	4,916	e.	32	n.	27	5	14	11	6.1	11.6	0.0
Helena	4,110	87	112	25.66	29.89	− .08	37.6	− 4.4	62	19	46	7	2	29	32	32	26	65	1.71	+ 0.6	17	5,903	sw.	36	sw.	5	2	4	24	7.9	6.3	0.0
Kalispell	2,973	48	56	26.79	29.87	− .09	39.2	− 3.3	65	26	47	13	3	31	33	34	28	68	1.48	+ 0.4	12	4,219	nw.	31	w.	5	3	14	13	6.6	2.4	0.0
Miles City	2,371	26	48																														
Rapid City	3,259	50	58	26.48	29.97	+ .02	34.6	− 8.9	65	14	44	4	4	26	34	30	24	67	4.27	+ 2.0	13	6,233	n.	28	n.	1	3	10	17	7.4	24.7	0.0
Cheyenne	6,088	84	101	23.79	29.86	− .05	31.6	−10.0	60	7	41	− 4	4	22	40	27	22	70	3.97	+ 2.1	19	11,479	w.	60	w.	5	3	10	17	7.2	41.5	3.5
Lander	5,372	60	68	24.47	29.88	− .06	35.3	− 6.9	62	9	46	5	4	25	35	30	23	67	3.13	+ 0.7	11	3,777	w.	36	w.	5	5	15	10	6.5	29.6	0.0
Sheridan	3,790	10	47	25.97	29.93	.....	36.4	.....	64	13	46	4	4	27	36	31	27	74	3.45	.....	19	4,886	nw.	38	nw.	14	7	9	14	6.5	15.5	0.0
Yellowstone Park	6,200	11	48	23.68	29.88	− .08	30.6	− 6.4	52	19	39	− 3	1	22	36	26	22	73	1.33	0.0	21	6,051	s.	42	sw.	14	2	8	20	7.7	4.8	T.
North Platte	2,821	11	51	26.91	29.87	− .05	40.5	− 8.5	72	14	51	17	4	30	39	35	30	75	3.42	+ 1.3	15	7,792	n.	40	ne.	11	12	4	14	5.9	6.9	0.0
Middle Slope.							**47.3**	**− 6.4**											**63**	**1.94**	**− 0.2**									**5.5**		
Denver	5,292	106	113	24.52	29.83	− .07	38.8	− 8.9	68	9	49	6	4	29	37	32	26	66	2.56	+ 0.4	13	7,356	n.	44	n.	17	2	16	12	7.0	28.3	0.0
Pueblo	4,685	80	86	25.07	29.77	− .11	43.6	− 6.9	74	9	58	12	4	30	46	34	24	54	0.86	− 0.6	5	6,878	se.	54	nw.	21	6	17	7	5.7	4.3	0.0
Concordia	1,392	50	58	28.34	29.83	− .10	45.6	− 8.0	77	21	56	16	5	36	36	40	36	74	2.82	+ 0.4	12	7,503	e.	44	ne.	3	3	17	10	6.8	9.2	0.0
Dodge City	2,509	11	51	27.20	29.81	− .09	48.8	− 5.6	79	14	63	18	4	35	44	40	32	63	1.75	− 0.1	8	10,069	se.	44	n.	3	15	10	5	3.9	2.9	0.0
Wichita	1,358	139	158	28.34	29.77	− .16	51.0	− 5.6	83	17	63	21	4	39	36	44	37	66	1.56	− 1.1	9	12,056	s.	56	sw.	21	11	13	6	5.1	1.5	0.0
Altus	1,410	5					58.2	.....	89	16	72	26	4	45	44	.....	.....	.....		1.62	.....	4	.....	se.	.....	.....	.....	20	1	9	.....	0.0	0.0
Broken Arrow	765	11	52	28.97	29.78	.....	55.0	.....	87	17	66	23	5	44	36	49	44	73	3.82	.....	8	11,722	se.	48	w.	4	10	9	11	5.2	T.	0.0
Muskogee	652	4					57.9	.....	89	17	69	23	5	46	36	.....	.....	.....		3.79	.....		.....	w.	.....	.....	.....	15	9	6	.....	0.0	0.0
Oklahoma	1,214	10	47	28.50	29.78	− .14	56.2	− 3.4	88	17	68	26	4	44	40	46	37	56	2.11	− 0.7	6	12,345	s.	54	w.	11	12	15	3	4.4	T.	0.0
Southern Slope.							**59.4**	**− 3.0**											**48**	**0.24**	**− 1.4**									**3.2**		
Abilene	1,738	10	52	27.98	29.77	− .13	62.6	− 1.8	93	29	77	26	4	48	46	48	32	40	0.29	− 2.0	2	9,842	s.	39	w.	3	17	8	5	3.3	0.0	0.0
Amarillo	3,676	10	49	26.06	29.77	− .10	51.0	− 3.6	86	29	66	13	4	36	54	41	32	60	0.64	− 1.1	6	9,748	sw.	44	nw.	11	15	12	3	3.6	0.5	0.0
Del Rio	944	64	71	28.83	29.80	− .09	68.8	− 1.2	101	17	83	37	5	55	41	.....	.....	.....	0.02	− 1.9	1	8,208	se.	43	n.	3	17	11	2	2.6	0.0	0.0
Roswell	3,566	75	85	26.16	29.74	− .11	55.1	− 5.5	85	29	72	17	4	39	51	42	28	44	T.	− 0.5	0	7,549	w.	42	nw.	1	16	13	1	3.1	0.0	0.0
Southern Plateau.							**57.6**	**− 3.4**											**37**	**0.22**	**− 0.1**									**2.4**		
El Paso	3,762	110	133	26.02	29.74	− .09	60.1	− 3.7	86	30	73	36	20	47	36	43	21	28	0.03	− 0.2	1	11,797	w.	57	w.	17	22	8	0	2.1	0.0	0.0
Santa Fe	7,013	57	66	23.04	29.75	− .09	40.8	− 6.8	69	30	52	13	4	29	36	32	22	54	0.73	− 0.1	8	7,037	sw.	47	sw.	10	10	10	19	5.2	3.5	0.0
Flagstaff	6,908	8	57																														
Phoenix	1,108	76	81	28.66	29.81	− .06	64.6	− 2.0	94	30	80	42	2	50	39	48	30	33	0.00	− 0.4	0	4,763	e.	40	w.	16	22	8	0	1.7	0.0	0.0
Yuma	141	9	54	29.68	29.84	− .05	67.6	− 2.5	94	28	83	46	11	53	41	52	36	39	0.10	− 0.1	0	4,991	w.	36	w.	20	27	3	0	0.6	0.0	0.0
Independence	3,957	9	41	25.87	29.88	− .02	54.8	− 1.9	82	29	69	30	1	41	37	41	23	31	0.24	+ 0.1	3	6,814	nw.	35	n.	17	24	3	3	2.3	0.0	0.0
Middle Plateau.							**44.4**	**− 4.6**											**50**	**1.10**	**0.0**									**5.2**		
Reno	4,532	74	81	25.39	29.93	− .04	45.5	− 1.8	74	28	58	23	1	33	40	36	26	52	1.10	+ 0.5	3	6,878	w.	46	sw.	15	16	11	3	3.6	2.0	0.0
Tonopah	6,090	12	20	23.95	29.85	.....	44.8	.....	70	29	56	19	17	33	33	36	20	40	0.03	− 1.7	2	9,287	nw.	48	nw.	16	12	18	0	3.7	0.5	0.0
Winnemucca	4,344	18	56	25.52	29.93	− .03	43.6	− 3.5	72	29	58	21	24	30	42	34	24	54	0.80	− 0.1	6	6,338	sw.	42	w.	2	10	8	12	5.8	1.1	0.0
Modena	5,479	10	43	24.46	29.80	− .08	43.1	− 3.8	74	29	57	14	1	29	42	32	18	44	0.44	− 0.4	4	10,360	w.	54	sw.	10	16	11	3	3.8	0.5	0.0
Salt Lake City	4,360	163	203	25.47	29.85	− .07	44.0	− 6.1	68	30	52	22	3	36	25	37	29	60	3.16	+ 0.9	11	6,138	nw.	68	ne	17	5	6	19	7.5	14.3	0.0
Grand Junction	4,602	60	68	25.20	29.76	− .12	45.6	− 7.6	80	30	57	14	1	35	33	36	24	49	1.09	+ 0.3	8	5,056	nw.	42	sw.	10	3	16	11	6.6	4.5	0.0
Northern Plateau.							**44.9**	**− 4.0**											**63**	**1.84**	**+ 0.7**									**6.1**		
Baker	3,471	48	53	26.35	29.95	− .05	40.5	− 3.0	67	26	51	15	3	30	36	34	26	63	0.98	0.0	11	5,006	se.	28	w.	8	7	13	10	5.4	3.6	0.0
Boise	2,739	78	86	27.06	29.93	− .05	45.4	− 4.7	67	27	56	23	3	35	31	40	33	66	1.32	+ 0.1	9	5,024	nw.	37	nw.	2	9	7	14	6.1	1.7	0.0
Lewiston	757	40	48	29.12	29.94	− .05	49.5	− 3.4	75	26	59	32	1	40	33	.....	.....	.....	2.24	+ 2.4	14	3,182	e.	29	n.	28	2	7	21	.....	2.8	0.0
Pocatello	4,477	60	68	25.31	29.85	− .09	40.6	− 6.2	63	30	49	19	1	32	32	34	28	65	2.28	+ 0.3	14	8,077	sw.	40	sw.	5	2	12	16	7.5	12.2	0.0
Spokane	1,929	101	110	27.87	29.93	− .06	44.6	− 3.1	74	26	54	23	3	35	35	38	30	62	1.43	+ 0.1	13	5,148	sw.	33	w.	5	8	16	6	5.8	3.9	0.0
Walla Walla	991	57	65	28.89	29.96	− .05	49.0	− 3.8	76	26	58	32	3	40	27	41	33	58	2.80	+ 1.1	13	4,786	s.	37	w.	2	7	11	12	5.9	0.5	0.0
North Pacific Coast Region.							**46.0**	**− 3.0**											**78**	**3.15**	**− 0.1**									**6.0**		
North Head	211	11	56	29.84	30.08	+ .03	43.6	− 3.9	51	9	47	36	9	40	15	41	38	82	4.02	+ 0.8	20	11,804	nw.	64	nw.	2	6	16	8	5.7	T.	0.0
Port Angeles	29	8	53	30.03	30.06	.....	42.8	.....	62	25	51	30	8	35	29	.....	.....	.....	1.26	− 0.7	10	6,079	sw.	35	sw.	2	12	8	10	5.0	0.2	0.0
Seattle	125	215	250	29.92	30.05	+ .02	45.6	− 3.8	71	26	53	30	9	38	27	41	37	77	3.46	+ 0.8	16	5,827	se.	40	s.	4	5	3	22	7.5	2.4	0.0
Tacoma	213	113	120	29.81	30.05	+ .02	45.6	− 3.3	72	26	54	30	9	38	31	43	40	80	2.47	− 0.3	15	4,712	sw.	30	sw.	7	4	12	14	6.8	1.5	0.0
Tatoosh Island	86	7	57	29.93	30.03	+ .03	44.0	− 2.1	53	25	48	36	1	40	12	41	39	83	3.40	− 2.9	16	9,114	w.	66	w.	2	14	9	7	4.6	0.0	0.0
Yakima	1,071	4					48.2	.....	82	26	62	24	3	34	42	.....	.....	.....	0.53	.....	8	.....	nw.	.....	.....	.....	6	14	6	.....	2.0	0.0
Medford	1,425	4					48.4	.....	81	26	61	26	23	36	44	.....	.....	.....	0.99	.....	10	.....	nw.	.....	.....	.....	7	8	15	.....	T.	.....
Portland, Oreg	153	68	106	29.90	30.06	.00	48.2	− 3.0	78	26	56	35	23	41	34	44	39	75	4.75	+ 1.7	19	4,286	nw.	32	w.	2	5	5	20	7.3	T.	0.0
Roseburg	510	9	57	29.54	30.09	+ .02	49.2	− 1.7	82	26	59	30	18	39	43	43	37	70	2.67	+ 0.2	16	2,481	n.	17	sw.	14	6	18	6	5.3	0.0	0.0
Middle Pacific Coast Region.							**53.0**	**− 0.7**											**67**	**1.72**	**− 0.4**									**3.2**		
Eureka	62	73	89	30.05	30.12	+ .01	48.0	− 1.5	61	26	54	37	22	42	20	45	43	85	3.12	− 0.8	9	6,201	n.	36	n.	17	16	4	10	4.5	0.0	0.0
Mount Tamalpais	2,375	11	18	27.53	30.01	− .04	49.8	− 0.3	76	26	57	32	20	42	28	42	34	62	2.48	+ 1.0	7	18,095	nw.	92	nw.	1	17	8	5	3.4	0.0	0.0
Point Reyes Light	490	7	18	29.46	29.98	.....	48.4	− 0.2	64	26	52	40	17	45	18	.....	.....	.....	0.87	.....	5	21,730	nw.	87	nw.	19	17	6	7	3.7	0.0	0.0
Red Bluff	332	50	56	29.61	29.97	− .06	58.0	− 1.1	90	28	71	37	17	45	42	48	36	52	1.06	− 0.8	5	5,894	nw.	30	se.	8	22	4	4	2.6	0.0	0.0
Sacramento	69	106	117	29.91	29.98	− .03	57.1	− 0.9	85	26	70	36	1	45	38	49	42	62	1.36	− 0.6	3	7,181	s.	35	se.	15	21	4	5	2.6	0.0	0.0
San Francisco	155	208	243	29.85	30.02	− .03	54.9	+ 1.2	79	26	62	44	27	48	33	48	44	72	1.36	− 0.5	3	9,077	w.	42	w.	20	20	5	5	3.0	0.0	0.0
San Jose	141	12	110	29.89	30.04	.....	55.0	− 2.1	85	26	68	33	21	42	45	.....	.....	.....	0.92	− 0.5	4	5,312	nw.	28	sw.	15	23	2	5	2.6	0.0	0.0
South Pacific Coast Region.							**57.6**	**− 0.9**											**68**	**0.90**	**− 0.1**									**3.0**		
Fresno	327	89	98	29.63	29.98	− .01	59.4	− 1.8	89	29	72	38	1	47	34	49	38	54	0.49	− 0.2	2	6,101	nw.	38	nw.	17	25	1	4	T.	0.0	0.0
Los Angeles	338	159	191	29.61	29.98	− .01	58.8	− 0.6	81	27	67	45	10	50	28	51	46	70	1.00	− 0.1	4	4,756	sw.	30	nw.	17	17	7	6	3.4	0.0	0.0
San Diego	87	62	70	29.89	29.98	− .01	57.6	− 0.6	77	5	64	45	18	51	23	52	48	75	0.47	− 0.3	3	5,176	sw.	33	nw.	17	17	9	4	3.3	0.0	0.0
San Luis Obispo	201	32	40	29.82	30.04	− .01	54.6	− 0.6	80	27	65	36	18	44	39	47	42	72	1.65	+ 0.2	6	3,572	nw.	21	w.	20	20	4	6	3.3	0.0	0.0
West Indies.																																	
San Juan, P. R	82	8	54	29.93	30.02	.....	77.5	.....	90	17	84	69	8	71	18	.....	.....	.....	1.59	− 2.3	8	8,382	se.	33	e.	8	16	13	1	3.1	0.0	0.0
Panama Canal.																																	
Balboa Heights	118	7	97	29.72	29.84	− .01	82.4	+ 0.9	94	5	90	73	21	75	21	75	72	77	3.02	− 0.1	8	6,026	nw.	34	ne.	17	3	24	3	5.8	0.0	0.0
Colon	36	7	97	29.81	29.85	− .02	83.0	+ 2.3	93	12	88	75	21	77	17	76	74	78	1.72	− 2.6	9	8,528	n.	27	n.	30	8	17	5	4.9	0.0	0.0
Alaska.																																	
Juneau	80	11	49	.....	.....	.....	36.8	.....	57	30	44	14	2	30	26	32	27	71	4.64	.....	14	3,146	e.	20	ne.	2		74	19	7.0	6.3	0.0

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during April, 1920, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	11			0.13														0.13			
Albany, N. Y.	5			1.11														0.43			
Alpena, Mich.	21			0.89														0.28			
Amarillo, Tex.	10			0.26														0.26			
Anniston, Ala.	1	1:23 p. m.	4:00 p. m.	0.74	3:06 p. m.	3:37 p. m.	0.06	0.08	0.19	0.32	0.40	0.50	0.63	0.67							
	1–2	11:00 p. m.	3:00 a. m.	1.22	11:52 p. m.	1:40 a. m.	0.04	0.12	0.25	0.31	0.37	0.41	0.57	0.67	0.74	0.87	0.94				
	20	2:22 p. m.	5:28 p. m.	1.64	2:50 p. m.	4:01 p. m.	0.05	0.08	0.18	0.32	0.35	0.45	0.64	0.79	0.95	1.08	1.09	1.12	1.46		
		9:41 p. m.	10:15 p. m.	0.81	9:57 p. m.	10:10 p. m.	0.06	0.24	0.59	0.75											
Asheville, N. C.	2			1.53														0.57			
Atlanta, Ga.	2			0.83														0.68			
Atlantic City, N. J.	4			0.82														0.38			
Augusta, Ga.	2	6:00 a. m.	9:40 a. m.	1.56	6:28 a. m.	6:45 a. m.	0.04	0.27	0.53	0.85	0.92										
	12	7:50 p. m.	9:45 p. m.	0.70	8:28 p. m.	8:48 p. m.	0.03	0.07	0.16	0.44	0.66										
Baker, Oreg.	1–2			0.27														(*)			
Baltimore, Md.	2			1.09														0.41			
Bentonville, Ark.	18	10:55 p. m.	11:50 p. m.	0.64	11:22 p. m.	11:46 p. m.	0.04	0.09	0.21	0.37	0.49	0.66									
Binghamton, N. Y.	13			0.58														0.21			
Birmingham, Ala.	1	10:24 a. m.	5:28 p. m.	1.82	12:00 n.	12:14 p. m.	0.04	0.26	0.69	0.87											
	1–2	8:12 p. m.	D. N. a. m.	1.97	10:04 p. m.	11:06 p. m.	0.39	0.06	0.19	0.35	0.49	0.57	0.63	0.71	0.83	0.89	1.08	1.37	1.51		
	16	5:57 a. m.	8:14 a. m.	0.64	6:23 a. m.	6:52 a. m.	0.01	0.10	0.20	0.21	0.23	0.42	0.54								
	20	11:29 a. m.	6:27 p. m.	1.63	1:34 p. m.	2:06 p. m.	0.06	0.11	0.36	0.65	0.92	1.22	1.30	1.33							
Bismarck, N. Dak.	19–20			0.30														(*)			
Block Island, R. I.	28			1.08														0.68			
Boise, Idaho.	15			0.54														0.16			
Boston, Mass.	5			0.66														0.48			
Buffalo, N. Y.	27			0.52														0.16			
Burlington, Vt.	13			1.31														0.38			
Cairo, Ill.	1			0.78														0.46			
Canton, N. Y.	12–13			0.79														(*)			
Charles City, Iowa.	19–20			1.26														(*)			
Charleston, S. C.	19	9:43 a. m.	11:35 a. m.	2.63	10:15 a. m.	11:17 a. m.	0.18	0.07	0.15	0.23	0.50	0.67	0.89	1.05	1.18	1.27	1.77	2.37	2.45		
Charlotte, N. C.	12	7:47 p. m.	10:40 p. m.	0.86	9:27 p. m.	9:47 p. m.	0.28	0.11	0.26	0.38	0.56										
Chattanooga, Tenn.	20	12:18 p. m.	11:41 p. m.	1.87	7:05 p. m.	7:20 p. m.	0.85	0.12	0.62	0.88											
Cheyenne, Wyo.	17–18			1.21														(*)			
Chicago, Ill.	30			0.92														0.28			
Cincinnati, Ohio.	19	5:36 p. m.	6:35 p. m.	0.72	5:40 p. m.	5:57 p. m.	0.01	0.19	0.34	0.56	0.61										
Cleveland, Ohio.	21			0.91														0.50			
Columbia, Mo.	1			0.84														0.61			
Columbia, S. C.	2			0.83														0.40			
Columbus, Ohio.	20			1.27														0.53			
Concord, N. H.	28			1.46														0.33			
Concordia, Kans.	25			0.92														0.11			
Corpus Christi, Tex.	26			0.07														0.04			
Dallas, Tex.	8	7.15 p. m.	8.50 p. m.	0.84	8.02 p. m.	8.16 p. m.	0.01	0.24	0.53	0.67											
Davenport, Iowa.	19–20	5.10 p. m.	3.00 a. m.	1.07	7.52 p. m.	8.10 p. m.	0.13	0.29	0.51	0.72	0.81										
Dayton, Ohio.	20			1.68														0.52			
Del Rio, Tex.	24			0.02														T.			
Denver, Colo.	17–18			1.07														*			
Des Moines, Iowa.	1			0.96														0.45			
Detroit, Mich.	20–21			0.79														*			
Devils Lake, N. Dak.	24			0.12														0.12			
Dodge City, Kans.	11			0.68														0.15			
Drexel, Nebr.	18			0.80														0.56			
Dubuque, Iowa.	19			1.82														0.46			
Duluth, Minn.	20			0.55														0.20			
Eastport, Me.	6			0.95														0.39			
Elkins, W. Va.	30			0.97														0.42			
Ellendale, N. Dak.	19–20			0.76														*			
El Paso, Tex.	19			0.03														0.03			
Erie, Pa.	27			0.84														0.36			
Escanaba, Mich.	1			0.46														0.29			
Eureka, Calif.	8			0.67														0.20			
Evansville, Ind.	12			0.90														0.28			
Flagstaff, Ariz.																					
Fort Smith, Ark.	24			1.34														0.39			
Fort Wayne, Ind.	20			1.44														0.46			
Fort Worth, Tex.	24			0.35														0.17			
Fresno, Calif.	9			0.22														0.10			
Galveston, Tex.	26			0.49														0.30			
Grand Haven, Mich.	22			0.24														0.19			
Grand Junction, Colo.	16–17			0.47														*			
Grand Rapids, Mich.	20			0.93														0.42			
Green Bay, Wis.	22			0.76														*			
Greenville, S. C.	12	3:10 p. m.	7:20 p. m.	1.27	5:39 p. m.	6:03 p. m.	0.09	0.25	0.40	0.67	1.00	1.06									
	20	5:30 p. m.	D. N. p. m.	1.90	8:53 p. m.	9:18 p. m.	0.03	0.16	0.47	0.87	1.21	1.35									
Hannibal, Mo.	1			0.68														0.59			
Harrisburg, Pa.	2			0.68														0.38			
Hartford, Conn.	5			0.56														0.37			
Hatteras, N. C.	27–28			1.84														0.85			
Havre, Mont.	27–28			0.95														(*)			
Helena, Mont.	9			0.27														0.16			
Houghton, Mich.	22			0.48														0.23			
Houston, Tex.	26			0.32														0.29			
Huron, S. Dak.	22			1.01														0.20			
Independence, Calif.	15			0.22														0.13			
Indianapolis, Ind.	20	12:05 a. m.	5:56 a. m.	2.29	3:06 a. m.	3:44 a. m.	0.09	0.12	0.29	0.53	0.75	0.88	1.10	1.60	2.03						
Iola, Kans.	26			0.45														0.23			
Jacksonville, Fla.	12			0.56														0.38			
Kalispell, Mont.	28			0.57														0.22			
Kansas City, Mo.	15	8:35 p. m.	10:45 p. m.	1.11	9:40 p. m.	10:06 p. m.	0.36	0.08	0.17	0.30	0.52	0.68	0.72								
	15–16	D. N. p. m.	1:00 a. m.	0.58	12:13 a. m.	12:36 a. m.	0.03	0.08	0.21	0.33	0.46	0.53									
Keokuk, Iowa.	16			0.40														0.26			
Key West, Fla.	9	D. N. a. m.	D. N. a. m.	0.66	1:21 a. m.	1:31 a. m.	0.01	0.35	0.52												
	16	5:55 p. m.	8:10 p. m.	1.01	6:00 p. m.	6:21 p. m.	0.01	0.22	0.63	0.78	0.87	0.89									
Knoxville, Tenn.	1			2.69														0.48			
La Crosse, Wis.	1			1.05														0.44			
Lander, Wyo.	10–11			1.03														(*)			
Lansing, Mich.	20			0.33														0.19			
Lewiston, Idaho.	13			0.30														0.22			

* Self-register not in use.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during April, 1920, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Lexington, Ky	20			1.83														0.55			
Little Rock, Ark	15–16	9:45 p. m.	D. N. a. m.	1.59	10:32 p. m.	10:47 p. m.	0.16	0.25	0.48	0.68											
Los Angeles, Calif	15			0.73														0.10			
Louisville, Ky	20	D. N. a. m.	1:22 p. m.	2.08	3:46 a. m.	4:13 a. m.	T.	0.12	0.69												
Ludington, Mich	20			0.93														0.47			
Lynchburg, Va	2			0.62														0.52			
Macon, Ga	2	5:00 a. m.	8:00 a. m.	0.83	5:13 a. m.	5:27 a. m.	0.01	0.22	0.40	0.50											
	22	6:26 p. m.	6:57 p. m.	0.68	6:37 p. m.	6:56 p. m.	0.02	0.21	0.28	0.44	0.66										
	26	4:12 p. m.	7:20 p. m.	1.16	6:34 p. m.	6:57 p. m.	0.14	0.05	0.20	0.66	0.90	0.98									
Madison, Wis	20			0.84														0.47			
Marquette, Mich	22–23			0.88														(*)			
Memphis, Tenn	1			1.65														0.61			
Meridian, Miss	1	8:00 p. m.	D. N. p. m.	1.84	9:12 p. m.	10:23 p. m.	0.56	0.17	0.25	0.26	0.31	0.34	0.37	0.41	0.56	0.69	0.74	1.30	1.77		
	20	9:20 a. m.	1:10 p. m.	2.57	9:24 a. m.	10:04 a. m.	0.02	0.07	0.12	0.15	0.20	0.26	0.37	0.54	0.62						
					10:55 a. m.	11:55 a. m.	0.87	0.24	0.28	0.44	0.64	0.67	0.88	0.94	1.04	1.20	1.43	1.56			
	26	D. N. a. m.	6:30 a. m.	0.73	4:26 a. m.	4:50 a. m.	0.06	0.08	0.17	0.40	0.44	0.50									
Miami, Fla	12	5:11 p. m.	D. N. p. m.	1.30	7:43 p. m.	8:31 p. m.	0.22	0.32	0.41	0.43	0.55	0.63	0.72	0.82	0.89	0.94	1.00				
Milwaukee, Wis	20			0.28														0.13			
Minneapolis, Minn	22			0.40														0.14			
Mobile, Ala	9	D. N. a. m.	7:55 a. m.	2.48	4:40 a. m.	5:27 a. m.	0.26	0.30	0.54	0.61	0.75	0.90	1.10	1.25	1.39	1.54	1.59				
	16	D. N. a. m.	6:20 a. m.	1.44	2:32 a. m.	3:21 a. m.	0.13	0.25	0.37	0.44	0.54	0.66	0.74	0.80	0.84	0.89	0.95				
Modena, Utah	14			0.11														0.08			
Montgomery, Ala	2	D. N. a. m.	D. N. a. m.	2.20	1:28 a. m	2:55 a. m.	0.04	0.10	0.27	0.64	0.89	1.14	1.34	1.34	1.35	1.36	1.46	1.70	1.89	2.14	
Moorhead, Minn	19–20			0.51														(*)			
Mount Tamalpais, Calif	15			0.82														0.20			
Nantucket, Mass	13			0.87														0.62			
Nashville, Tenn	20	12:15 p. m.	4:00 p. m.	2.45	12:35 p. m.	1:39 p. m.	0.03	0.13	0.44	0.78	0.99	1.00	1.01	1.05	1.13	1.19	1.48	1.87	1.97		
New Haven, Conn	28			0.91														0.24			
New Orleans, La	8–9	D. N. p. m.	9:00 a. m.	5.44	12:06 a. m.	1:08 a. m.	0.01	0.27	0.65	0.96	1.17	1.44	1.62	1.84	2.59	2.97	3.22	3.66	3.77		
					5:21 a. m.	6:11 a. m.	3.81	0.09	0.23	0.37	0.52	0.68	0.89	1.04	1.16	1.22	1.38				
	26	1:23 p. m.	7:34 p. m.	2.23	1:39 p. m.	2:34 p. m.	0.07	0.06	0.21	0.54	0.82	0.99	1.10	1.19	1.35	1.51	1.65	1.76			
New York, N. Y	23			0.41														0.39			
Norfolk, Va	13			1.41														0.68			
Northfield, Vt	12–13			1.24														(*)			
North Head, Wash	4			1.28														0.16			
North Platte, Nebr	10			1.41														0.42			
Oklahoma, Okla	25			1.11														0.46			
Omaha, Nebr	18			0.66														0.20			
Oswego, N. Y	4–5			0.55														(*)			
Palestine, Tex	11			0.29														0.29			
Parkersburg, W. Va	20	9:14 a. m.	3:07 p. m.	2.04	9:36 a. m.	9:51 a. m.	0.02	0.24	0.45	0.54											
Pensacola, Fla	16	2:50 a. m.	5:30 a. m.	1.23	3:58 a. m.	4:14 a. m.	0.59	0.19	0.41	0.56	0.60										
	26–27	4:30 p. m.	3:30 a. m.	3.99	9:32 p. m.	9:55 p. m.	0.78	0.11	0.31	0.39	0.52	0.57									
					12:18 a. m.	1:13 a. m.	1.99	0.15	0.29	0.55	0.92	1.32	1.48	1.51	1.57	1.62	1.72	1.80			
Peoria, Ill	19			1.67														0.40			
Philadelphia, Pa	21			0.57														0.35			
Phoenix, Ariz	(‡)			(‡)																	
Pierre, S. Dak	18–19			1.46														(*)			
Pittsburgh, Pa	20			0.78														0.35			
Pocatello, Idaho	16			1.00														(*)			
Point Reyes Light, Calif	14			0.47														0.10			
Port Angeles, Wash	19			0.35														0.15			
Port Huron, Mich	22			0.53														0.28			
Portland, Me	28			1.78														0.42			
Portland, Oreg	13			0.22														0.21			
Providence, R. I	28			1.10														0.35			
Pueblo, Colo	17			0.45														0.08			
Raleigh, N. C	21	D. N. a. m.	D. N. a. m.	0.75	1:17 a. m.	1:27 a. m.	0.05	0.22	0.57												
Rapid City, S. Dak	16–17			1.89														(*)			
Reading, Pa	2			1.37														0.42			
Red Bluff, Calif	9			0.54														0.28			
Reno, Nev	15			0.87														0.16			
Richmond, Va	17			0.54														0.53			
Rochester, N. Y	22			0.26														0.20			
Roseburg, Oreg	9			0.41														0.11			
Roswell, N. Mex	25–26			T.														T.			
Sacramento, Calif	9			0.36														0.25			
Saginaw, Mich	22			0.31														0.25			
St. Joseph, Mo	18–19	D. N. a. m.	6:25 a. m.	1.42	2:26 a. m.	3:30 a. m.	0.08	0.05	0.18	0.35	0.52	0.66	0.75	0.92	1.04	1.08	1.12	1.21	1.30		
		8:15 p. m.	D. N. a. m.	1.18	11:03 p. m.	11:20 p. m.	0.26	0.47	0.74	0.82	0.85										
St. Louis, Mo	12			1.03														0.35			
St. Paul, Minn	19–20			0.61														(*)			
Salt Lake City, Utah	15			0.47														0.29			
San Antonio, Tex	26			0.70														0.60			
San Diego, Calif	9			0.24														0.22			
Sand Key, Fla	10	11:23 a. m.	5:30 p. m.	1.68	11:45 a. m.	12:24 p. m.	0.03	0.20	0.47	0.55	0.65	0.73	0.83	0.97	1.02						
	12	4:35 p. m.	8:45 p. m.	2.25	6:34 p. m.	7:40 p. m.	0.08	0.06	0.20	0.45	0.69	0.88	1.07	1.29	1.62	1.75	1.92	2.00	2.13		
Sandusky, Ohio	20			0.99														0.63			
Sandy Hook, N. J	20–21	10:45 p. m.	11:45 a. m.	1.93	9:42 a. m.	10:32 a. m.	0.87	0.10	0.33	0.53	0.61	0.67	0.70	0.75	0.83	0.89	0.94				
San Francisco, Calif	9			0.48														0.21			
San Jose, Calif	9			0.66														0.31			
San Luis Obispo, Calif	9			0.72														0.16			
Santa Fe, N. Mex	18–19			0.28														(*)			
Sault Ste. Marie, Mich	1–2			1.25														(*)			
Savannah, Ga	3	3:52 p. m.	8:08 p. m.	1.41	4:24 p. m.	5:06 p. m.	0.10	0.24	0.45	0.52	0.55	0.61	0.69	0.84	0.90	0.93					
Scranton, Pa	16–17			0.55														(*)			
Seattle, Wash	19			0.95														0.16			
Sheridan, Wyo	17			1.20														(*)			
Shreveport, La	8	4:30 p. m.	4:48 p. m.	0.61	4:32 p. m.	4:42 p. m.	0.01	0.30	0.59												
	11	5:45 p. m.	9:20 p. m.	0.89	7:07 p. m.	7:25 p. m.	0.12	0.22	0.38	0.56	0.64										
	24–25	9:10 p. m.	D. N. a. m.	0.81	12:22 a. m.	12:58 a. m.	0.05	0.18	0.29	0.33	0.35	0.44	0.52	0.62	0.65						
Sioux City, Iowa	28–29			1.72														(*)			
Spokane, Wash	8			0.28														(*)			
Springfield, Ill	19	7:04 p. m.	10:55 p. m.	1.79	8:02 p. m.	8:56 p. m.	0.12	0.22	0.43	0.61	0.97	1.20	1.36	1.37	1.43	1.48	1.54	1.66			
Springfield, Mo	19			0.31														0.24			
Syracuse, N. Y	27–28			0.84														(*)			
Tacoma, Wash	4			0.63														0.10			
Tampa, Fla	9	3:38 p. m.	8:50 p. m.	0.88	4:36 p. m.	4:57 p. m.	0.06	0.12	0.25	0.42	0.54	0.56									
	12	11:35 a. m.	4:15 p. m.	2.87	1:00 p. m.	2:01 p. m.	0.07	0.06	0.15	0.19	0.26	0.52	0.82	1.06	1.40	1.69	1.88	2.55	2.61		
	16	9:13 a. m.	3:55 p. m.	2.02	12:22 p. m.	1:19 p. m.	0.33	0.14	0.15	0.30	0.65	0.84	0.88	0.94	1.01	1.15	1.23	1.33			

* Self-register not in use

‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during April, 1920, at all stations furnished with self-registering gages*—Concluded.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.													
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Tatoosh Island, Wash	18			0.37														0.17			
Taylor, Tex	25			0.42														0.37			
Terre Haute, Ind	19	D. N. a. m.	8:25 a. m.	1.24	3:20 a. m.	4:09 a. m.	0.03	0.07	0.15	0.25	0.33	0.36	0.49	0.57	0.65	0.81	0.87				
Thomasville, Ga	3	12:32 p. m.	5:42 p. m.	1.57	2:27 p. m.	2:48 p. m.	0.19	0.19	0.35	0.60	0.72	0.75									
	27	4:28 p. m.	7:32 p. m.	0.93	5:44 p. m.	6:04 p. m.	0.04	0.17	0.49	0.65	0.75										
Toledo, Ohio	20			1.46														0.68			
Tonopah, Nev	9			0.02														(*)			
Topeka, Kans	11			1.09														0.54			
Trenton, N. J	21			0.81														0.49			
Valentine, Nebr	18			1.60														(*)			
Vicksburg, Miss	1	8:15 a. m.	7:40 p. m.	3.65	1:57 p. m.	2:24 p. m.	0.25	0.14	0.31	0.39	0.40	0.50	0.53								
					3:31 p. m.	5:11 p. m.	0.89	0.10	0.35	0.56	0.78	0.94	1.01	1.10	1.15	1.23	1.27	1.40	2.09	2.29	
	8-9	6:54 p. m.	6:05 a. m.	2.24	10:07 p. m.	10:29 p. m.	0.13	0.09	0.25	0.50	0.68	0.74									
	25-26	D. N. p. m.	D. N. a. m.	2.64	1:01 a. m.	2:29 a. m.	0.42	0.17	0.24	0.46	0.50	0.72	0.90	1.00	1.18	1.24	1.29	1.58	1.89	2.04	
Walla Walla, Wash	9			0.47														0.25			
Washington, D. C	20			0.75														0.45			
Wausau, Wis	22			1.13														(*)			
Wichita, Kans	26			0.27														0.16			
Williston, N. Dak	21			0.20														0.07			
Wilmington, N. C	13			0.65														0.51			
Winnemucca, Nev	15			0.44														0.11			
Wytheville, Va	2			0.94														0.46			
Yankton, S. Dak	21			0.58														0.42			
Yellowstone Park, Wyo	13-14			0.42														(*)			

* Self-register not in use.

TABLE III.—*Data furnished by the Canadian Meteorological Service, April, 1920.*

Stations.	Altitude above M. S. L. Jan. 1, 1919.	Pressure.			Temperature.						Precipitation.		
		Station, reduced to mean of 24 hours.	Sea-level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷ 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*° F.*	*Inches.*	*Inches.*	*Inches.*
St. John's, N. F	125	29.50	29.64	−0.25	34.7	+ 0.2	39.9	29.5	50	20	5.53	+1.37	4.0
Sydney, C. B. I	48	29.74	29.79	− .10	35.9	+ 0.9	42.6	29.2	56	20	9.90	+6.05	23.0
Halifax, N. S	88	29.65	29.76	− .20	38.4	+ 0.6	46.2	30.6	63	20	8.53	+4.35	8.5
Yarmouth, N. S	65	29.69	29.78	− .18	39.7	+ 0.8	45.5	34.0	64	27	4.84	+1.45	8.0
Charlottetown, P. E. I	38	29.72	29.76	− .14	36.6	+ 1.4	41.9	31.3	55	22	4.97	+2.32	14.5
Chatham, N. B	28	29.77	29.80	− .10	36.1	+ 0.6	44.0	28.1	60	17	5.53	+2.90	23.0
Father Point, Que	20	29.78	29.80	− .13	33.3	+ 0.1	39.2	27.5	54	18	3.66	+2.08	19.9
Quebec, Que	296	29.46	29.78	− .21	36.0	+ 0.9	42.7	29.4	62	17	6.49	+4.40	8.6
Montreal, Que	187	29.56	29.77	− .23	40.2	+ 0.5	47.5	32.9	64	23	5.07	+2.83	7.0
Stonecliffe, Ont	489	29.15	29.78	− .24	34.5	− 3.4	47.7	21.3	66	10	2.91	+1.35	4.1
Ottawa, Ont	236	29.51	29.77	− .25	40.7	+ 0.7	48.9	32.5	67	19	4.44	+2.94	3.0
Kingston, Ont	285	29.47	29.79	− .23	40.0	0.0	47.1	32.9	63	17	3.39	+1.60	6.8
Toronto, Ont	379	29.38	29.79	− .23	40.1	− 0.7	47.6	32.6	60	18	3.26	+0.89	5.9
Cochrane, Ont	930												
White River, Ont	1,244	28.44	29.78	− .26	29.8	− 3.2	39.5	20.1	57	− 8	1.99	+0.74	10.1
Port Stanley, Ont	592	29.16	29.82	− .20	38.8	− 2.2	46.8	30.9	66	18	4.12	+1.65	9.8
Southampton, Ont	656	29.05			35.9	− 2.8	43.3	28.6	64	10	3.65	+1.85	11.4
Parry Sound, Ont	688	29.09	29.78	− .24	38.3	+ 0.7	47.8	28.8	67	14	2.26	+0.35	4.0
Port Arthur, Ont	644	29.14	29.87	− .16	32.4	− 1.1	40.6	24.3	55	2	1.09	−0.63	
Winnipeg, Man	760	29.15	30.02	.00	29.9	− 6.0	39.3	20.2	60	− 2	0.30	−0.75	0.4
Minnedosa, Man	1,690	28.15	30.03	+ .02	26.1	− 9.9	35.8	16.5	56	−14	0.29	−0.77	0.4
Le Pas, Man	860												
Qu'Appelle, Sask	2,115	27.71	30.01	+ .02	26.7	− 0.7	35.4	18.0	51	−10	0.95	−0.53	4.6
Medicine Hat, Alb	2,144	27.58	29.87	− .05	36.3	− 8.2	46.2	26.5	66	2	0.67	−0.07	1.6
Moose Jaw, Sask	1,759												
Swift Current, Sask	2,392	27.32	29.99	+ .03	31.1	−10.2	39.2	23.0	57	− 2	0.46	−0.47	2.9
Calgary, Alb	3,428	26.35	30.02	+ .12	28.9	−10.7	37.2	20.7	57	− 8	2.14	+1.50	19.2
Banff, Alb	4,521	25.24	29.89	− .01	30.0	− 5.3	40.4	19.6	56	−11	1.63	+0.55	15.9
Edmonton, Alb	2,150	27.66	30.00	+ .11	27.5	−12.4	35.8	19.2	54	−15	0.84	−0.04	3.9
Prince Albert, Sask	1,450	28.48	30.10	+ .12	27.8	− 8.3	38.4	17.3	56	−15	0.33	−0.50	2.1
Battleford, Sask	1,592	28.26	30.05	+ .08	27.7	− 9.5	36.6	18.9	52	−12	0.96	+0.49	6.1
Kamloops, B. C	1,262	28.68	29.96	+ .03	45.7	− 3.2	57.1	34.4	76	13	0.63	+0.24	
Victoria, B. C	230	29.76	30.02	+ .01	45.4	− 1.4	51.9	39.0	65	30	1.45	−0.92	0.1
Barkerville, B. C	4,180	25.53	29.89	− .03	29.2	− 3.9	38.4	20.1	49	− 8	4.88	+3.06	48.1
Triangle Island, B. C	680												
Prince Rupert, B. C	170												
Hamilton, Bermuda	151	29.88	30.04	−0.01	65.4	+ 1.5	71.3	59.5	76	52	1.44	−2.74	0.0

SEISMOLOGICAL REPORTS.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, D. C., June 3, 1920.]

TABLE I.—*Noninstrumental earthquake reports, April, 1920.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1920.	*H. m.*		° ′	° ′			*Sec.*			
Apr. 13	4 35	Calexico	32 41	115 30	3	2	3–5	Rumbling	Felt by several	H. M. Rouse.
20	6 20	Eureka	40 45	124 15	3	1	2	None	Felt by many	J. M. Jones.
		ILLINOIS.								
30	15 12	Centralia	38 30	89 10	4	2	Few.	....do	....do	D. Tuft.
		TENNESSEE.								
7	20 45	Springville	35 52	85 27	2	1		....do	Heavy jar.	H. A. Boden.

TABLE 2.—*Instrumental reports, April, 1920.*

[For significance of symbols and abbreviations, and for a description of stations and instruments, see the REVIEW for January, 1920, pp. 62-63.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
		ALABAMA. *Spring Hill College, Mobile.*						
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 19	.....	eP	21 11 10	.....	.....	.....	.....	Only a trace on E. W.; N.—S. undamped; E.—W. damped.
			21 11 30	.....	.....	.....	.....	
			21 11 48	3	.....	*3,200	.....	
		S?	21 13 26	.....	.....	.....	.....	
		L?	21 13 50	.....	.....	.....	.....	
		M	21 14 02	3	.....	*2,000	.....	
		M	21 14 20	3	.....	*3,000	.....	
		F	21 33 00	.....	.....	.....	.....	
		ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*						
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 18	.....	eP_E	21 08 39	.....	.....	.....	.....	Record irregular; instrument apparently not in good adjustment.
		eP_N	21 09 43	.....	.....	.....	.....	
		L_E	21 09 30	.....	.....	.....	.....	
		M_E	21 10 42	.....	40	.....	.....	
		M_N	21 11 43	.....	.....	10	.....	
		F	21 15 ..	.....	.....	.....	.....	
		ARIZONA. *U. S. C. & G. S. Magnetic Observatory, Tucson.*						
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 6	.....	eP_E	16 54 38	.....	.....	.....	.....	Times uncertain. N. not in operation.
		eL_E	16 54 49	.....	.....	.....	.....	
		M_E	16 55 12	.....	50	.....	.....	
		C_E	16 58 ..	.....	.....	.....	.....	
		F_E	17 01 ..	.....	.....	.....	.....	
19	.....	iP_E	21 10 51	3	.....	.....	2,170	Probably in Mexico. N. not in operation.
		eS_E	21 14 29	.....	.....	.....	.....	
		L_E	21 16 40	.....	.....	.....	.....	
		M_E	21 17 41	5	120	.....	.....	
		C_E	21 19 ..	.....	.....	.....	.....	
		F_E	21 28 ..	.....	.....	.....	.....	
		COLORADO. *Sacred Heart College, Denver.*						
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 5	.....	L_N	23 31 ..	.....	.....	.....	.....	Visible activity at intervals during day.
		M_N	23 41 ..	.....	.....	.....	.....	
		F_N	23 49 ..	.....	.....	.....	.....	
7	.....	L_N	21 23 ..	.....	.....	.....	.....	P not discernible; waves very small but clear.
		M_N	21 27 ..	.....	.....	.....	.....	
		F_N	21 30 ..	.....	.....	.....	.....	
14–15	.....	L_N	2 30 ..	.....	.....	.....	.....	Wavelets discernible.
		F_N	4 20 ..	.....	.....	.....	.....	
19	.....	L_N	21 09 30	.....	.....	.....	.....	4 sets of waves at an interval of about 2 minutes. P not discernible.
		L_E	21 09 30	.....	.....	.....	.....	
		M_N	21 10 ..	3–4	.....	*2,000	.....	
		M_E	21 10 ..	3–4	*2,000	.....	.....	
		C	21 19 ..	.....	.....	.....	.....	
		F	21 26 ..	.....	.....	.....	.....	

*Trace amplitude.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
		DISTRICT OF COLUMBIA. *U. S. Weather Bureau, Washington.*						
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 11	.....	eP	23 16 17	.....	.....	.....	.....	
		S	23 26 03	.....	.....	.....	.....	
		L?	23 41 30	.....	.....	.....	.....	
		F	23 50 *ca.*	.....	.....	.....	.....	
16	.....	eL	23 03 30	.....	.....	.....	.....	
		L	21 10 ..	16	.....	.....	.....	
		F	23 20 ..	.....	.....	.....	.....	
18	.....	P	21 31 38	.....	.....	.....	.....	
		L?	21 35 ..	.....	.....	.....	.....	
		F	21 50 *ca.*	.....	.....	.....	.....	
19	.....	P	21 12 10	.....	.....	.....	2,900	
		S	21 16 48	.....	.....	.....	.....	L not defined.
		F	21 45 ..	.....	.....	.....	.....	
		DISTRICT OF COLUMBIA. *Georgetown University, Washington.*						
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 6	.....	eP	16 49 37	.....	.....	.....	.....	Heavy micros.
		S_N?	16 55 10	.....	.....	.....	.....	
		F	17 12 ..	.....	.....	.....	.....	
11	.....	e	23 16 00	.....	.....	.....	.....	Do.
		S?	23 26 17	.....	.....	.....	.....	
		L_N	23 52 04	18	.....	.....	.....	
		F	23 56 ..	.....	.....	.....	.....	
16	.....	e	22 46 29	.....	.....	.....	.....	Do.
		L_E	23 10 18	19	.....	.....	.....	
		L_N	23 10 18	16	.....	.....	.....	
		F	23 20 ..	.....	.....	.....	.....	
18	.....	S	21 31 49	.....	.....	.....	.....	e masked in very heavy micros.
		eL	21 33 12	10	.....	.....	.....	
		F	22 13 ..	.....	.....	.....	.....	
		VERTICAL.						
		S_E	*21 21 49*	.....	.....	.....	.....	Micros.
		L_E	*21 35 17*	8	.....	.....	.....	
		F_E	*21 55* ..	.....	.....	.....	.....	
19	.....	P	21 12 13	.....	.....	.....	.....	No distinct M. Phases identical on photographic machine.
		S_E	21 16 55	.....	.....	.....	.....	
		S_N	21 16 56	.....	.....	.....	.....	
		eL_E	21 18 42	7	.....	.....	.....	
		eL_N	21 18 42	7	.....	.....	.....	
		F	21 55 ..	.....	.....	.....	.....	
		VERTICAL.						
		P_E	*21 12 12*	.....	.....	.....	.....	
		eL_E	*21 18 42*	8	.....	.....	.....	
		L_E	*21 28 13*	10	.....	.....	.....	
		F	*21 55* ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental Reports, April, 1920*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
ILLINOIS. *U. S. Weather Bureau, Chicago.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 6	.....	P.....	16 49 27	.....	.....	.....	3,000	
		S.....	16 54 23	.....	.....	.....	.....	
		L.....	17 00 20	15	.....	.....	.....	
		F.....	17 30 *ca.*	.....	.....	.....	.....	
6	.....	P?.....	19 31 15	.....	.....	.....	.....	High winds.
		L.....	19 55 30	30	.....	.....	.....	
		L.....	20 09 ..	18	.....	.....	.....	
		F.....	20 30 *ca.*	.....	.....	.....	.....	
11	.....	eP.....	23 18 15	.....	.....	.....	5,000?	
		S.....	23 24 48	.....	.....	.....	.....	
		L?.....	23 33 30	.....	.....	.....	.....	
		F.....	24 30 *ca.*	.....	.....	.....	.....	
13	.....	P.....	14 33 35	.....	.....	.....	.....	
		S.....	14 34 17	.....	.....	.....	.....	
		L.....	14 34 43	.....	.....	.....	.....	
		F.....	14 40 00	.....	.....	.....	.....	
13	.....	P?.....	17 33 05	.....	.....	.....	.....	
		S?.....	17 37 18	.....	.....	.....	.....	
		L.....	17 44 45	.....	.....	.....	.....	
		F.....	18 *ca.* ..	.....	.....	.....	.....	
16	.....	P.....	22 31 40?	.....	.....	.....	1,300?	
		S.....	22 36 45	.....	.....	.....	.....	
		L.....	22 42 50	18	.....	.....	.....	
		L.....	22 42 59	18	.....	.....	.....	
		L.....	23 10 ..	16	.....	.....	.....	
17	.....	F.....	0 20 *ca.*	.....	.....	.....	.....	
18	.....	P.....	21 26 50	.....	.....	.....	.....	
		S.....	21 27 45	.....	.....	.....	.....	
		L?.....	21 28 10	.....	.....	.....	.....	
		F.....	21 40 *ca.*	.....	.....	.....	.....	
19	.....	iP.....	21 11 55	.....	.....	.....	2,700	
		S.....	21 16 17	.....	.....	.....	.....	
		L?.....	21 18 15	30	.....	.....	.....	
		F.....	22 20 *ca.*	.....	.....	.....	.....	
MARYLAND. *U. S. C. & G. S. Magnetic Observatory, Cheltenham.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 18	.....	eP_E.....	21 31 11	.....	.....	.....	.....	Phases ill-defined except PR_I.
		eP_N.....	21 31 42	.....	.....	.....	.....	
		PR_I.....	21 32 12	3	.....	.....	.....	
		S_E.....	21 33 28	9	.....	.....	.....	
		e_E.....	21 35 28	.....	10	.....	.....	
		e_N.....	21 35 02	.....	.....	10	.....	
		L_N.....	21 40 46	9	.....	.....	.....	
		C_N.....	21 42 ..	9	.....	.....	.....	
		F_E.....	22 20 ..	.....	.....	.....	.....	
		F_N.....	22 19 ..	9	.....	.....	.....	
19	.....	P.....	21 12 12	3	.....	.....	2,930	Probably in Mexico.
		PR_{IN}.....	21 12 39	.....	.....	.....	.....	
		e_E.....	21 12 59	.....	.....	.....	.....	
		S_N.....	21 16 50	.....	.....	.....	.....	
		eL_N.....	21 24 01	.....	.....	.....	.....	L uncertain.
		eL_E.....	21 26 45	.....	.....	.....	.....	
		M_E.....	21 30 22	.....	10	.....	.....	
		M_N.....	21 30 39	8	.....	10	.....	
		F.....	21 40 ..	.....	.....	.....	.....	
MASSACHUSETTS. *Harvard University, Cambridge.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 6	.....	$?_N$.....	12 02 52	9	.....	.....	.....	Microseismic group.
		$?_N$.....	12 03 37	8	.....	.....	.....	Less definite on E.
		F.....	12 04 48	.....	.....	.....	.....	
11	.....	$?_N$.....	23 25 16	5 5.5	.....	.....	.....	
		$?_N$.....	23 25 30	5 8.0	.....	.....	.....	
		$?_N$.....	23 25 54	5 10.0	.....	.....	.....	Amplitude *500.
		$?_N$.....	23 26 05	5 10.0	.....	.....	.....	Do.
		$?_N$.....	23 26 10	5 10.0	.....	.....	.....	Do.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
MASSACHUSETTS. *Harvard University, Cambridge*—Continued.								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 13	.....	$L?_E$...	(17 37 44)	8	.....	.....	.....	N record looks like microseismic, chiefly of 6s. per., rarely 7 and 8, having increased A.
		to...	(17 42 21)	.....	.....	.....	.....	
16	.....	O?.....	22 27 42	.....	.....	.....	8,300?	Distance and O doubtful.
		$S_E?$...	22 49 03	6	.....	.....	.....	N masked by microseisms of 4s. per.
		e_E.....	22 50 54	6	.....	.....	.....	
		L_N.....	23 04 15	21	.....	.....	.....	
		L_N.....	23 04 48	22	.....	.....	.....	
		$M_N?$..	23 10 30	15	.....	.....	.....	A slightly increased.
		$M_E?$...	23 10 47	16	.....	.....	.....	Do.
		F.....	23 40 *ca*	.....	.....	.....	.....	
18	.....	O?.....	21 22 *ca*	.....	.....	.....	.....	*Cf.* next record.
		L_N.....	21 32 04	8	.....	.....	.....	
		$M_N?$..	21 32 56	7	.....	*1,000	.....	
		C_N.....	21 33 24	.....	.....	.....	.....	
		C_E.....	21 36 ..	.....	.....	.....	.....	Beginning and end lost in microseisms.
19	.....	O.....	21 07 48	.....	.....	.....	2,520	22°.68 of arc.
		$eP_N?$..	21 12 57	.....	.....	.....	.....	
		Pe.....	21 12 58	2	.....	.....	.....	Impulse from the east.
		P_{HIN}..	21 44 08	.....	.....	.....	.....	Phases much masked by microseisms.
		P_{HIE}..	21 14 12	.....	.....	.....	.....	
		S_E.....	21 17 04	6	.....	.....	.....	
		eL_E...	21 18 04	12	.....	.....	.....	
		eL_N...	21 18 13	8	.....	.....	.....	
		$F_E?$...	21 46 *ca*	.....	.....	.....	.....	

Both components failed to record at certain hours during the month.

*Trace amplitude.

NEW YORK. *Cornell University, Ithaca.*

1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 16	.....	L.....	23 05 ..	18	.....	.....	.....	
		F.....	23 28 ..	.....	.....	.....	.....	
18	.....	e.....	21 30 20	3	.....	.....	.....	Short period waves; may not be seismic.
		F.....	21 38 ..	.....	.....	.....	.....	
19	.....	P.....	21 12 25	4	.....	.....	.....	
		S.....	21 17 22	4	.....	.....	.....	
		L.....	21 21 40	28	.....	.....	.....	
		F.....	21 42 ..	.....	.....	.....	.....	

CANAL ZONE. *Panama Canal, Balboa Heights.*

1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 9	.....	P_L.....	4 00 22	.....	.....	.....	351	
		P_N.....	4 00 26	.....	.....	.....	.....	
		S_E.....	4 01 00	.....	.....	.....	.....	
		S_N.....	4 01 04	.....	.....	.....	.....	
		M_E.....	4 01 11	.....	*800	.....	.....	
		M_N.....	4 01 14	.....	.....	*1,000	.....	
		F_E.....	4 02 48	.....	.....	.....	.....	
		F_N.....	4 03 00	.....	.....	.....	.....	
27	.....	P_E.....	18 18 54	.....	.....	.....	85	
		P_N.....	18 18 54	.....	.....	.....	.....	
		S.....	18 19 04	.....	.....	.....	.....	
		M_E.....	18 19 06	.....	*2,000	.....	.....	
		M_N.....	18 18 58	.....	.....	*500	.....	
		F_E.....	18 19 30	.....	.....	.....	.....	
		F_N.....	18 19 50	.....	.....	.....	.....	

*Trace amplitude.

TABLE 2.—*Instrumental Reports, April, 1920*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 12	.....	eP_E	17 39 18	.....	.....	.....	.....	Very faint on N.
		eP_N	17 39 15	.....	.....	.....	.....	
		eL_E	17 39 21	.....	.....	.....	.....	
		eL_N	17 39 26	.....	.....	.....	.....	
		M_E	17 39 47	.....	10	.....	.....	
		C	17 40 ..	.....	.....	.....	.....	
		F	17 43 ..	.....	.....	.....	.....	
19	.....	P_E	21 13 02	.....	.....	.....	.....	Do.
		S_E	21 18 00	.....	.....	.....	.....	
		S_N	21 18 10	.....	.....	.....	.....	
		eL_E	21 22 25	.....	.....	.....	.....	
		M_E	21 23 35	.....	20	.....	.....	
		C_E	21 32 ..	.....	.....	.....	.....	
		F_E	21 36 ..	.....	.....	.....	.....	
		F_N	21 27 ..	.....	.....	.....	.....	
VERMONT. *U. S. Weather Bureau, Northfield.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 18	.....	e	21 30 50	.....	.....	.....	.....	
		eL?	21 34 ..	.....	.....	.....	.....	
		F	21 45 ..	.....	.....	.....	.....	
19	.....	e	21 17 ..	.....	.....	.....	.....	
		F	21 25 ..	.....	.....	.....	.....	
CANADA. *Dominion Observatory, Ottawa.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 6	.....	O?	16 43 22	.....	.....	.....	3,800?	
		iP?	16 50 25	.....	.....	.....	.....	
		S?	16 56 00	.....	.....	.....	.....	
		F	.....	.....	.....	.....	.....	Lost in micros about 17–10.
11	.....	e	23 25 08 to	.....	.....	.....	.....	
		F	24 00 00	.....	.....	.....	.....	Very irregular small waves possibly not seismic.
16	.....	$e?_E$	22 47 30	.....	.....	.....	.....	
		$e?_N$	22 48 48	.....	.....	.....	.....	
		eL	23 00 to	24	.....	.....	.....	
			23 12	17	.....	.....	.....	
		F	23 33 ..	.....	.....	.....	.....	
18	.....	e	21 29 28	2	.....	.....	.....	May not be seismic.
		e	21 29 55	4	.....	.....	.....	
		F	.....	.....	.....	.....	.....	Lost in micros about 21–35.
19	.....	O	21 06 26	.....	.....	.....	3,420	
		P	21 13 00	.....	.....	.....	.....	
		S	21 18 12	.....	.....	.....	.....	
		eL?	.....	.....	.....	.....	.....	
		F	21 55 ..	.....	.....	.....	.....	No regular sinusoidal periods. Irregular small waves with micros until F.
CANADA. *Dominion Meteorological Service, Toronto.*								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 2	.....	L	2 10 24	.....	.....	.....	.....	
		eL	2 11 30	.....	.....	.....	.....	
		eL	2 15 18	.....	.....	.....	.....	
		M	2 17 42	.....	*200	.....	.....	
		eL	2 27 06	.....	.....	.....	.....	
		F	2 47 18	.....	.....	.....	.....	
6	.....	S?	17 03 12	.....	.....	.....	.....	Other phases lost; light turned down.
		L	17 09 54	.....	.....	.....	.....	
6	.....	L?	19 37 06	.....	.....	.....	.....	
		L	19 46 12	.....	*50	.....	.....	
6	.....	L	20 04 18	.....	.....	.....	.....	
		L	20 16 18	.....	.....	.....	.....	
		M	20 17 48	.....	*100	.....	.....	
6	.....	L	21 12 24	.....	.....	.....	.....	
		M	21 17 48	.....	*200	.....	.....	
		F	21 23 36	.....	.....	.....	.....	
9	.....	L	15 07 24	.....	.....	.....	.....	
		L	15 10 48	.....	*50?	.....	.....	

* Trace amplitude.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
CANADA. *Dominion Meteorological Service, Toronto*—Continued.								
1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 11	.....	L	23 30 42	.....	.....	.....	.....	
		L	23 48 54	.....	*50	.....	.....	
		L	23 52 06	.....	.....	.....	.....	
16	.....	L?	22 48 00	.....	.....	.....	.....	
		L	22 57 18	.....	.....	.....	.....	
		eL	23 03 18	.....	.....	.....	.....	
		M	23 04 18	.....	*300	.....	.....	
		F	23 39 00	.....	.....	.....	.....	
18	.....	L	21?26 18	.....	.....	.....	.....	Paper paid out irregularly; record doubtful.
19	.....	P	21 13 24	.....	.....	.....	.....	P very minute; amplitude of S waves large; may be a dual quake.
		S	21 17 36	.....	.....	.....	.....	
		eS	21 19 00	.....	.....	.....	.....	
		i	21 27 06	.....	.....	.....	.....	
		i	21 28 06	.....	.....	.....	.....	
		eL	21 30 00	.....	.....	.....	.....	
		M	21 33 00	.....	*400	.....	.....	
		eL	21 40 00	.....	.....	.....	.....	
		F	.....	.....	.....	.....	.....	

* Trace amplitude.

CANADA. *Dominion Meteorological Service, Victoria.*

1920.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Apr. 2	.....	P	1?43 31	.....	.....	.....	.....	
		M	1 54 20	.....	*200	.....	.....	
		F	2 15 00	.....	.....	.....	.....	
2	.....	M	7 53 00	.....	*200	.....	.....	
		F	7 58 46	.....	.....	.....	.....	
2	.....	P	15 37 38	.....	.....	.....	.....	
		M	15 56 49	.....	*300	.....	.....	
		F	16 13 13	.....	.....	.....	.....	
6	.....	P	16 57 16	.....	.....	.....	.....	
		L	17 03 40	.....	.....	.....	.....	P may be S phase.
		M	17 07 36	.....	*500	.....	.....	
		F	17 26 47	.....	.....	.....	.....	
6	.....	S?	19?18 26	.....	.....	.....	.....	
		L	19 23 51	.....	.....	.....	.....	
		M	19 31 43	.....	*500	.....	.....	
		F	20 24 20	.....	.....	.....	.....	
6	.....	M	21 25 19	.....	*100	.....	.....	May not be seismic.
		F	21 27 17	.....	.....	.....	.....	
9	.....	P	15 07 08	.....	.....	.....	.....	
		M	15 14 04	.....	*200	.....	.....	
		F	15 21 01	.....	.....	.....	.....	
10	.....	M	8 36 49	.....	*100	.....	.....	
11	.....	P	23?14 11	.....	.....	.....	.....	P may be S phase.
		L	23 20 35	.....	.....	.....	.....	
		M	23 27 28	.....	*200	.....	.....	
		F	23 37 18	.....	.....	.....	.....	
16	.....	L	22 41 06	.....	.....	.....	.....	
		M	22 50 27	.....	*200	.....	.....	
		F	23 22 25	.....	.....	.....	.....	
18	.....	L	21 14 51	.....	.....	.....	.....	
		M	21 16 20	.....	*400	.....	.....	
		F	21 24 46	.....	.....	.....	.....	
19	.....	P	21 15 50	.....	.....	.....	2,030	
		S	21 19 17	.....	.....	.....	.....	
		L	21 24 12	.....	.....	.....	.....	
		M	21 29 36	.....	*1,000	.....	.....	
		F	21 53 12	.....	.....	.....	.....	

* Trace amplitude.

The following stations recorded no earthquakes during April, 1920:

CALIFORNIA. *Theosophical University, Point Loma.*

Reports for April, 1920, have not been received from the following stations:

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*
KANSAS. *University of Kansas, Lawrence.*
MISSOURI. *St. Louis University, St. Louis.*
NEW YORK. *Canisius College, Buffalo.*

For the reports of the stations at the University of California, Berkeley, Calif., and at the Lick Observatory, Mount Hamilton, Calif., see *Bulletin of the Seismographic Stations, University of California*. For the report of the University of Santa Clara station, see *Record of the Seismographic Stations, University of Santa Clara*.

TABLE 3.—*Late Reports.* (*Instrumental.*)

ALASKA. *U. S. C. & G. S. Magnetic Observatory, Sitka.*

[For significance of symbols and abbreviations, and for a description of stations and instruments, see the REVIEW for January, 1920, pp. 62-63.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Mar. 20	.....	L_E....	19 17 45	17	20	.....	.....	N out of adjustment.
		C_E....	19 23 ..	15	.....	.....	.....	
		F_E....	19 31 ..	8	.....	.....	.....	
29	.....	e_E....	5 09 55	.....	.....	.....	.....	Phases ill-defined; both components in poor adjustment.
		e_N....	5 10 57	.....	.....	.....	.....	
		eL_E...	5 10 35	.....	.....	.....	.....	
		eL_N...	5 11 27	10	.....	.....	.....	
		M_E....	5 11 32	12	1080	.....	.....	
		M_N....	5 12 27	8	.....	340	.....	
		C_E....	5 17 ..	8	.....	.....	.....	
		C_N....	5 15 ..	7	.....	.....	.....	
		F_E....	6 04 ..	8	.....	.....	.....	
		F_N....	5 44 ..	8	.....	.....	.....	

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu.*

1920.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Mar. 11	.....	eP....	12 30 30	20	.....	.....	.....	
		L.....	12 39 00	.....	.....	.....	.....	
		M.....	12 44 30	17	*200	*200	.....	
		C.....	12 48 ..	.....	.....	.....	.....	
		F.....	13 03 ..	18	.....	.....	.....	
11		P.....	19 02 00	.....	.....	.....	.....	
		L.....	19 04 00	.....	.....	.....	.....	
		M.....	19 10 30	18	*200	*200	.....	
		C.....	19 14 ..	17	.....	.....	.....	
		F.....	19 30 ..	.....	.....	.....	.....	
12	.....	eP....	15 45 00	21	.....	.....	.....	
		eL....	15 53 42	.....	.....	.....	.....	
		M.....	16 01 30	15	*300	*300	.....	
		C.....	16 06 ..	17	.....	.....	.....	
		F.....	16 26 ..	18	.....	.....	.....	
13	.....	P.....	4 21 42	15	.....	.....	.....	
		iS....	4 24 54	15	.....	.....	.....	
		eL....	4 28 00	.....	.....	.....	.....	
		M.....	4 32 00	20	*200	*200	.....	
		C.....	4 36 ..	20	.....	.....	.....	
		F.....	4 52 ..	17	.....	.....	.....	
15	.....	e.....	12 17 00	.....	.....	.....	.....	
		iP....	12 21 18	17	.....	.....	.....	Phases difficult to harmonize.
		iS....	12 24 42	17	.....	.....	.....	
		eL....	12 30 30	.....	.....	.....	.....	
		M.....	12 34 48	16	*1,800	*1,800	.....	
		C.....	12 40 ..	20	.....	.....	.....	
		F.....	13 51 ..	19	.....	.....	.....	
20	.....	iS....	18 53 18	15	.....	.....	.....	Judging from the time at the origin indicated by the Cheltenham and Vieques records, the first recorded motion is S.
		i.....	19 02 12	15	.....	.....	.....	
		L.....	19 08 54	.....	.....	.....	.....	
		M.....	19 12 36	19	*1,500	*1,500	.....	
		C.....	19 15 ..	18	.....	.....	.....	
		F.....	20 57 ..	17	.....	.....	.....	
22	.....	eP....	1 56 24	.....	.....	.....	.....	Phases doubtful.
		S.....	2 00 42	20	.....	.....	.....	
		eL....	2 02 56	.....	.....	.....	.....	
		M.....	2 13 00	17	*500	*500	.....	
		C.....	2 16 ..	17	.....	.....	.....	
		F.....	2 37 ..	18	.....	.....	.....	

*Trace amplitude.

HAWAII. *U. S. C. & G. S. Magnetic Observatory, Honolulu*—Con.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1920.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Mar. 22	.....	iP....	20 17 30	17	.....	.....	.....	
		iS....	20 20 36	17	.....	.....	.....	
		eL....	20 23 00	.....	.....	.....	.....	
		M.....	20 29 30	17	*1,700	*1,700	.....	
		C.....	20 36 ..	18	.....	.....	.....	
		F.....	21 46 ..	17	.....	.....	.....	
23	.....	eP....	15 32 48	.....	.....	.....	.....	Phases doubtful.
		S.....	15 41 30	.....	.....	.....	.....	Instrument not in operation from 28d 7h until 29d 19h
		eL....	15 51 06	.....	.....	.....	.....	
		M.....	15 53 ..	.....	*100	*100	.....	
		F.....	16 08 ..	19	.....	.....	.....	

*Trace amplitude.

MASSACHUSETTS. *Harvard University, Cambridge.*

1920.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Jan. 3	.....	O.....	6 43 14	0.1	.....	.....	0	Frost crack at station; bare frozen ground and protracted low temperatures.
		iM....	6 43 14	.....	.....	.....	.....	
		F.....	6 43 20	.....	.....	.....	.....	
4	.....	O.....	4 21 44	.....	.....	.....	3,530	Destructive earthquake reported in the state of Vera Cruz, Mexico, at Teocelo, Coscomatepec, Coutzlan, San Francisco, de la Pena; with rise of the sea at Port Barranca to 25 meters. Damped 1.5/1. W_1. 230 kms. per min. eP on microseisms of 6 secs. period.
		eP_E...	4 28 37	2	.....	.....	.....	
		eP_N...	4 28 40	2	.....	.....	.....	
		i_E....	4 28 45	3	.....	.....	.....	
		i_N....	4 28 49	3	.....	.....	.....	
		S_N....	4 33 56	6	.....	.....	.....	
		eL_N...	4 37 07	13	.....	.....	.....	
		M_E....	4 46 39	13	*2,500	.....	.....	
		F_E....	5 45 *ca*	.....	.....	.....	.....	
13	.....	O.....	23 plus..	.....	.....	.....	.....	In micros 6.5 secs. per.
14		L_E....	0 07 34	.....	.....	.....	.....	
		L_E?...	0 11 11	20	.....	.....	.....	
		L_N....	0 11 25	.....	.....	.....	.....	
		L_N....	0 23 48	20	.....	.....	.....	
		L_N....	0 29 12	18	.....	.....	.....	
		F_E?...	0 35 15	.....	.....	.....	.....	
24	.....	.....	.....	.....	.....	.....	.....	Pulsations from 23h to 24h. Possibly local and nonseismic.
27	.....	O?....	23 01 59	.....	.....	.....	2,550?	O and distance very doubtful.
		eP_E...	23 07 11	2	.....	.....	.....	
		eP_N...	23 07 17	2	.....	.....	.....	
		S_N....	23 11 26	8	.....	.....	.....	This record followed on 28th, by irregular waves up to 9h.
		S_E....	23 11 31	.....	.....	.....	.....	
		L_N?...	23 16 46	20	.....	.....	.....	
		L_N....	23 17 05 to 23 20 10	12	.....	.....	.....	
28	.....	F?....	0 10 *ca*	.....	.....	.....	.....	
30	.....	O?....	18 13 16	.....	.....	.....	4,790?	Distance from L-P.
		eP_N...	18 34 17	2	.....	.....	.....	P_E suppressed.
		P_{pl}...	18 36 12	6	.....	.....	.....	
		S?....	18 40 *ca*	.....	.....	.....	.....	Masked by local jars.
		L_N....	18 47 04	22	.....	.....	.....	
		L_E....	18 47 06	20	.....	.....	.....	
		F?$_E$...	19 40 *ca*	.....	.....	.....	.....	

*Trace amplitude.

Chart I. Hydrographs of Several Principal Rivers, April, 1920.

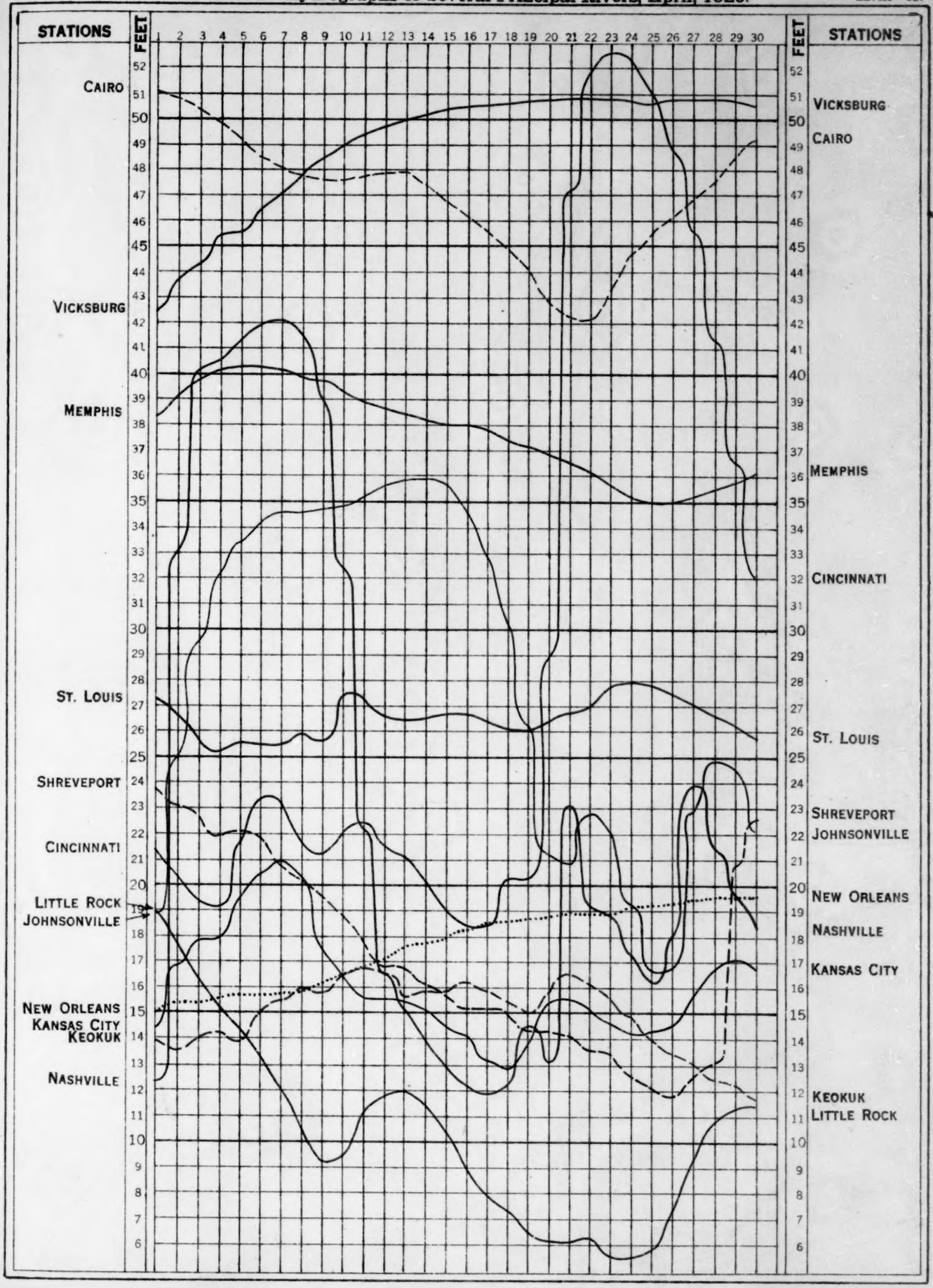


Chart II. Tracks of Centers of High Areas, April, 1920.

(Plotted by R. H. Weightman, Meteorologist.)

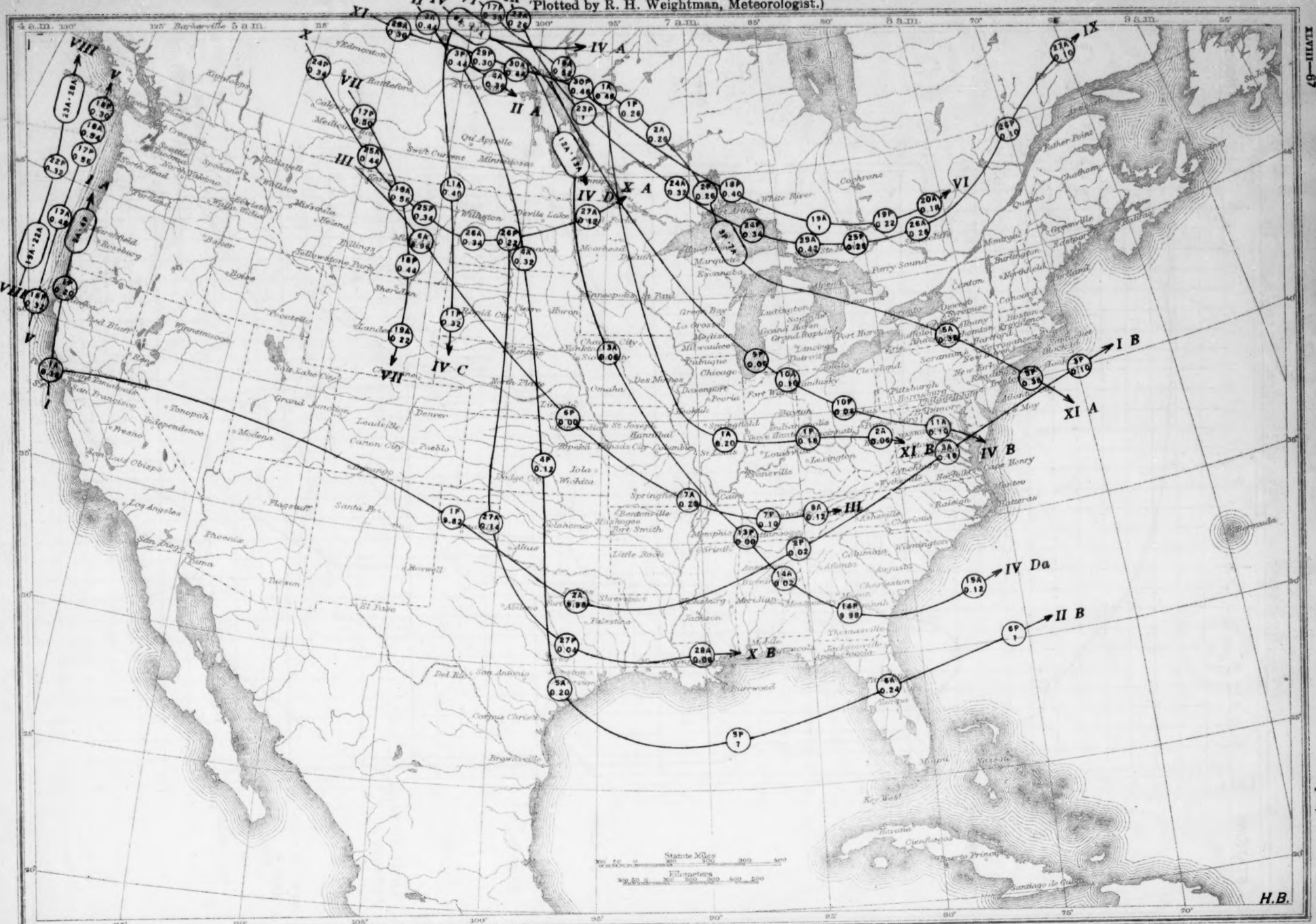


Chart III. Tracks of Centers of Low Areas, April, 1920.

Chart III. Tracks of Centers of Low Areas, April, 1920.

(Plotted by R. H. Weightman, Meteorologist.)

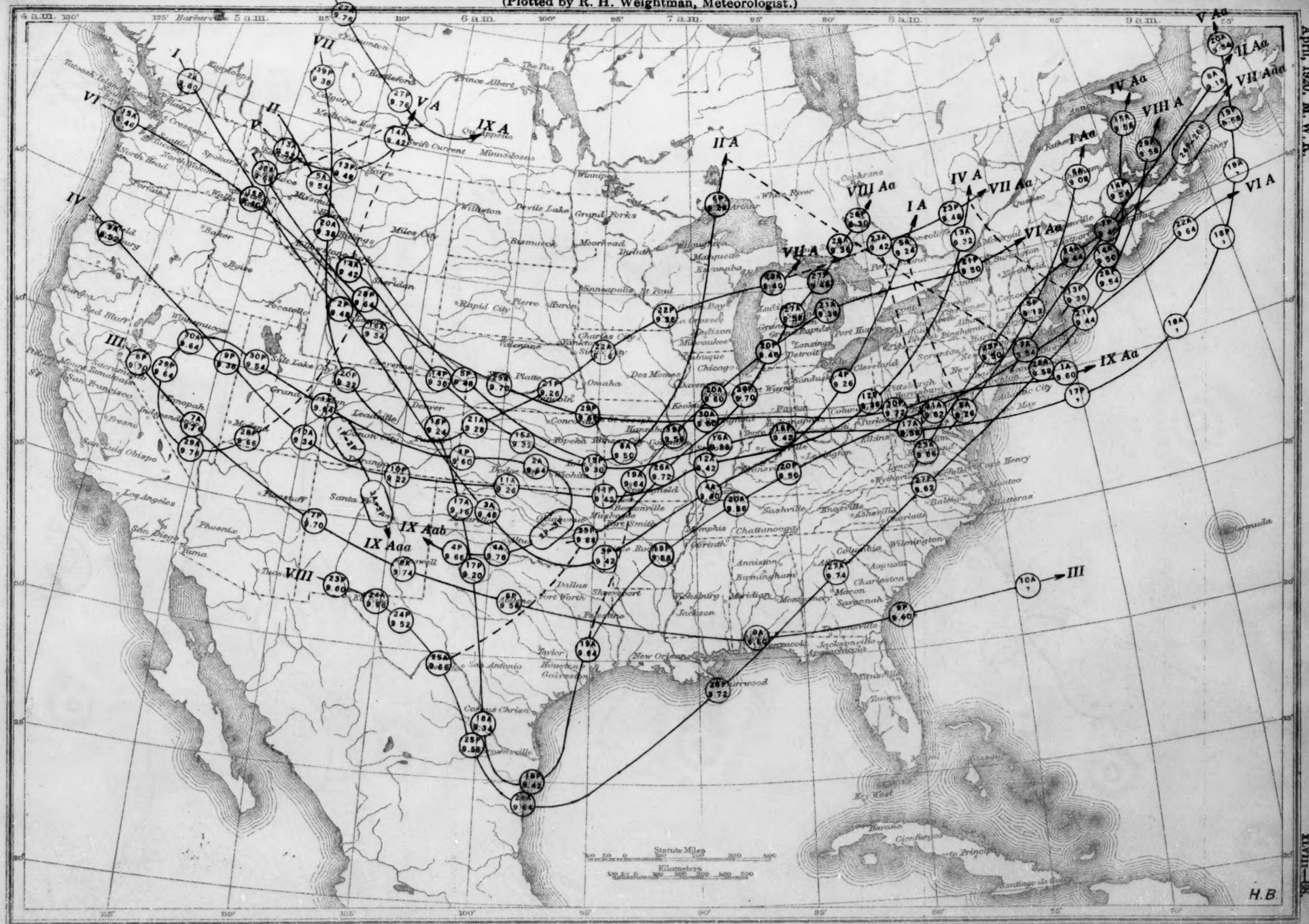


Chart IV. Departure (°F.) of the Mean Temperature from the Normal, April, 1920.

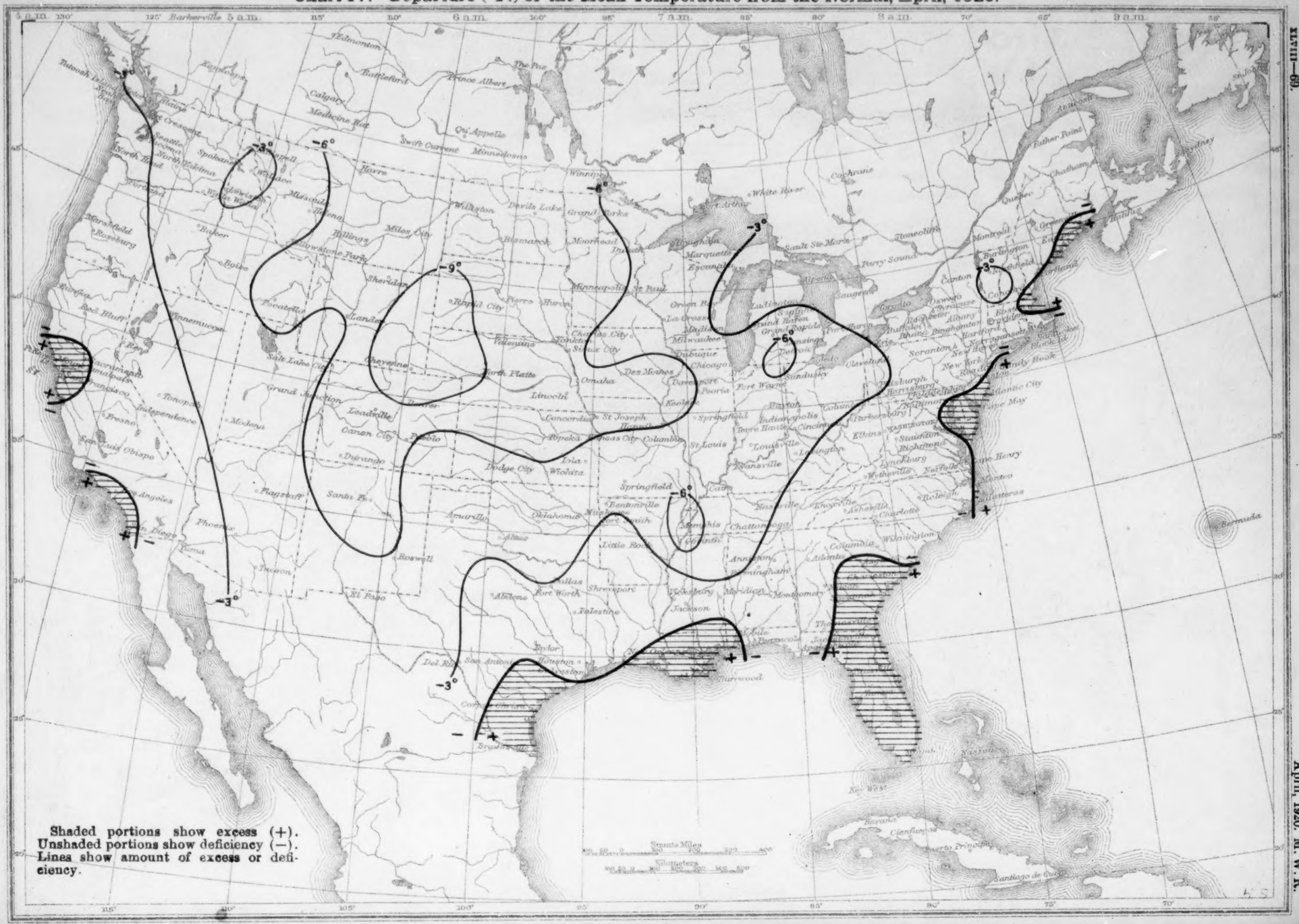


Chart V. Total Precipitation, Inches, April, 1920

Chart V. Total Precipitation, Inches, April, 1920.

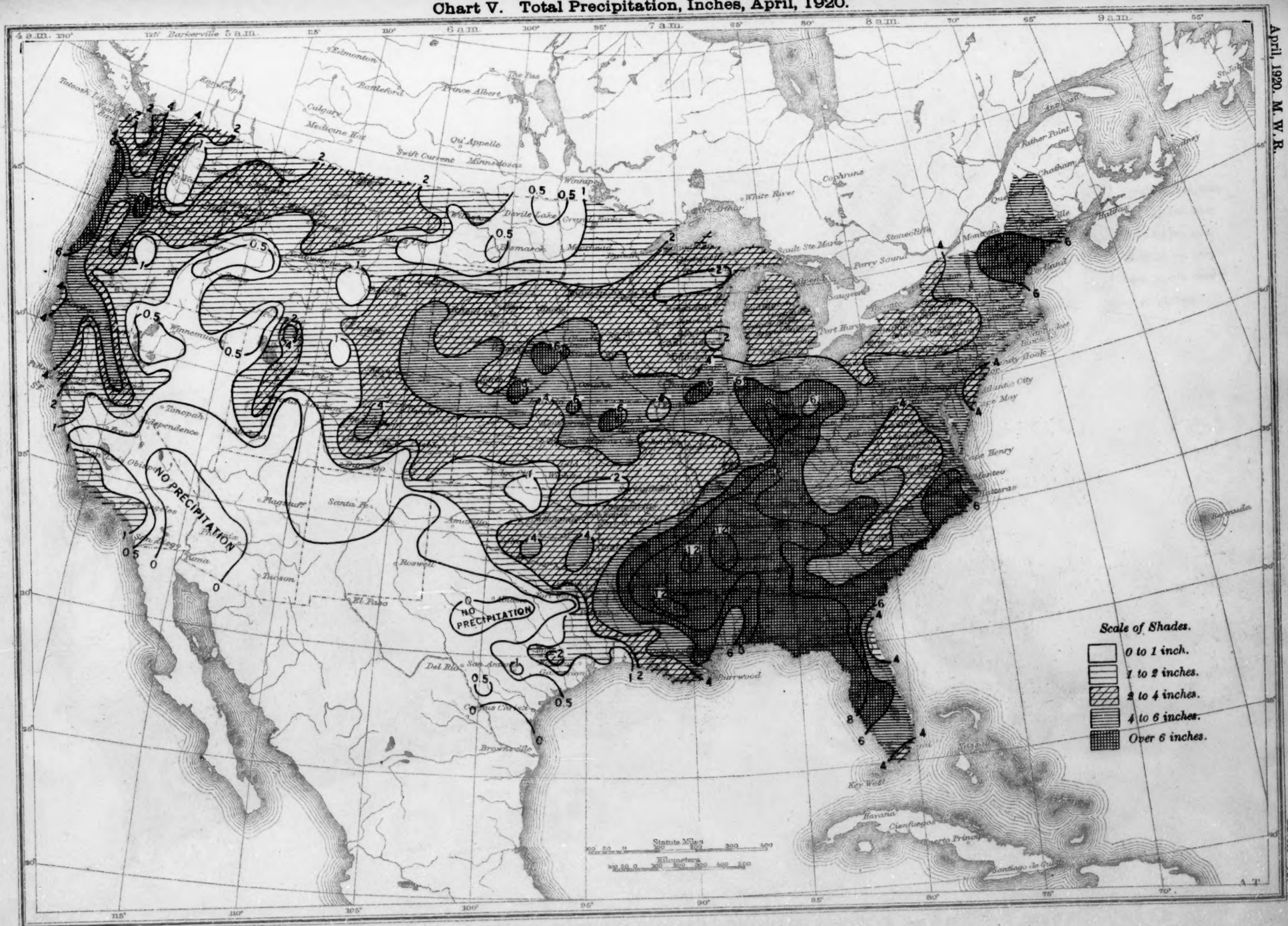


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, April, 1920.

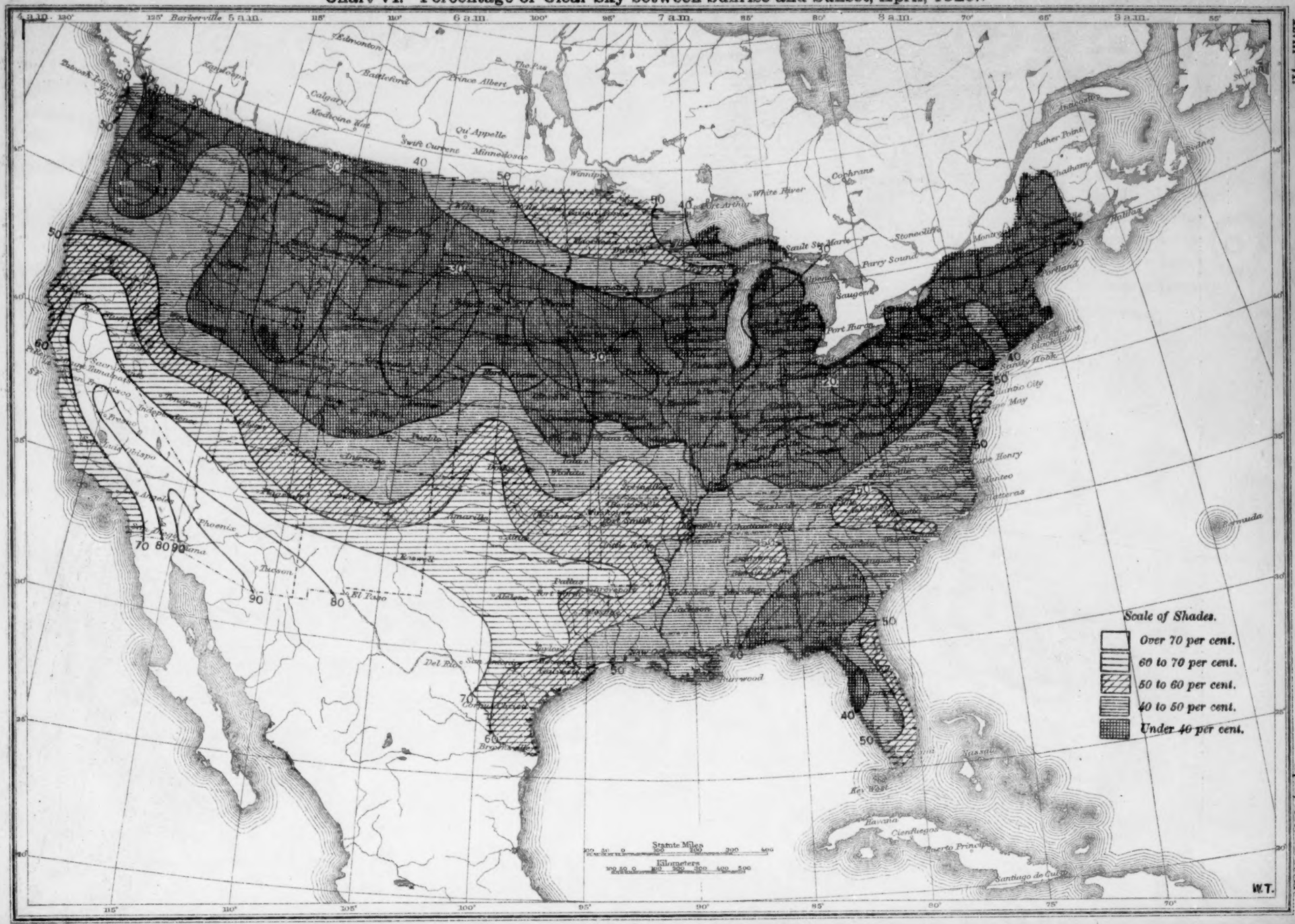


Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, April, 1920.

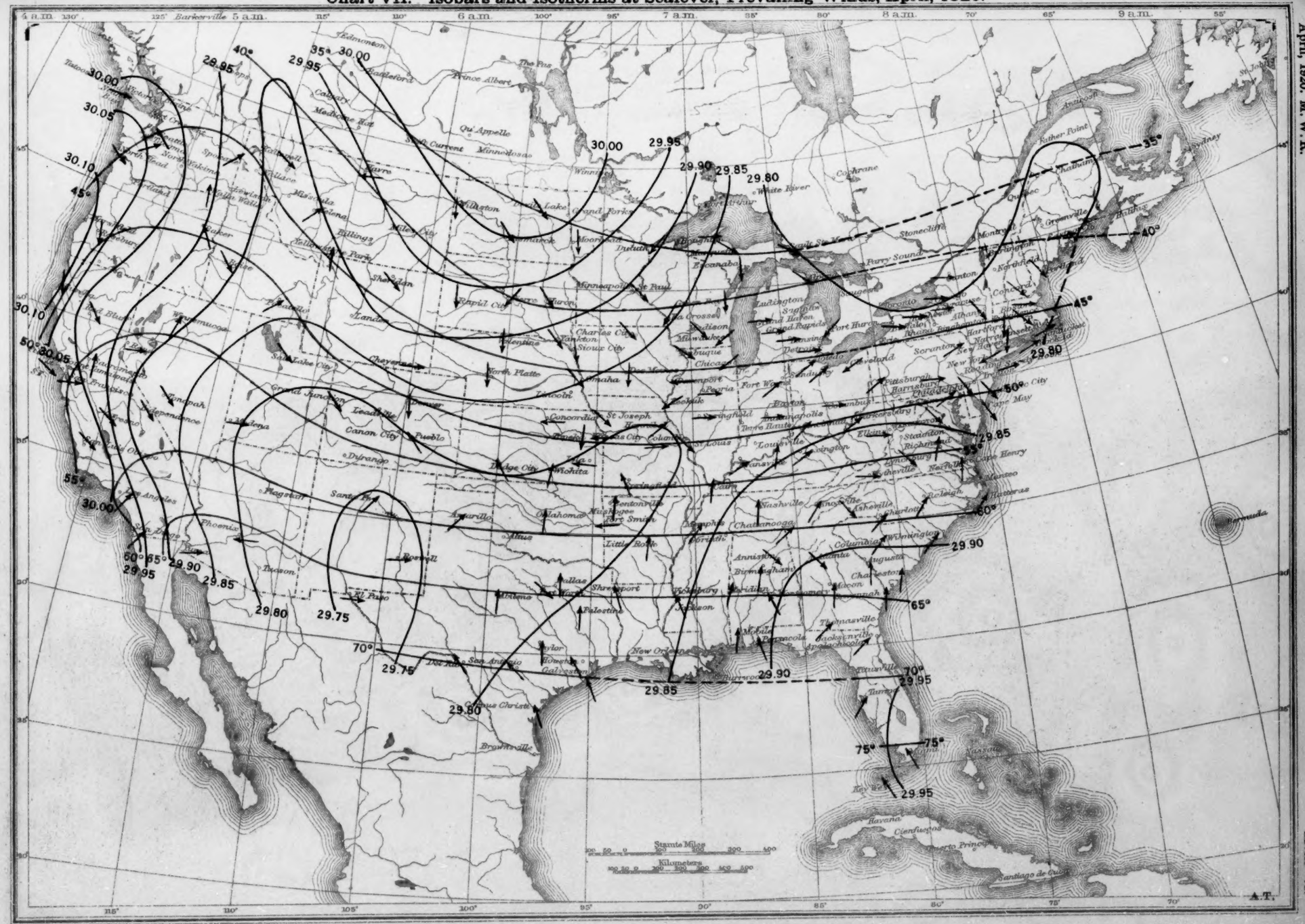

4 a.m.
5 a.m.
6 a.m.
7 a.m.
8 a.m.
9 a.m.
Barkerville
Edmonton
Prince Albert
Calgary
Medicine Hat
Qu'Appelle
Moose Jaw
Winnipeg
Minneapolis
St. Paul
Duluth
Port Arthur
White River
Cochrane
Father Point
Anticosti
Chatham
Stonecliffe
Parry Sound
Toronto
Ottawa
Montreal
Quebec
Portland
Boston
Albany
Buffalo
Cleveland
Detroit
Chicago
Milwaukee
Omaha
North Platte
Denver
Cheyenne
Salt Lake City
Great Falls
Helena
Billings
Miles City
Bismarck
Grand Forks
Moorhead
Devils Lake
Minot
Williston
Medicine Hat
Swift Current
Yellowstone Park
Spokane
Seattle
Portland
San Francisco
Los Angeles
San Diego
Phoenix
Tucson
Flagstaff
Santa Fe
Albuquerque
El Paso
Amarillo
Abilene
Dallas
Austin
San Antonio
Galveston
Corpus Christi
Brownsville
Laredo
Del Rio
Taylor
Palestine
Shreveport
Little Rock
Memphis
Vicksburg
New Orleans
Mobile
Pensacola
Jackson
Birmingham
Atlanta
Chattanooga
Nashville
Louisville
Cincinnati
Columbus
Indianapolis
Fort Wayne
Peoria
Davenport
Dubuque
La Crosse
Madison
Duluth
Ludington
Grand Haven
Saginaw
Port Huron
Detroit
Toledo
Sandusky
Erie
Buffalo
Rochester
Syracuse
Albany
Utica
Binghamton
Scranton
Harrisburg
Philadelphia
Atlantic City
New York
Boston
Portland
Concordia
St. Joseph
Kansas City
Topeka
Wichita
Hutchinson
Dodge City
Oklahoma
Fort Smith
Muskogee
Denison
Waco
Abilene
Fort Worth
Dallas
Austin
Houston
Galveston
Corpus Christi
Brownsville
Laredo
Del Rio
Taylor
Palestine
Shreveport
Little Rock
Memphis
Vicksburg
New Orleans
Mobile
Pensacola
Jackson
Birmingham
Atlanta
Chattanooga
Nashville
Knoxville
Asheville
Charlotte
Raleigh
Norfolk
Richmond
Lynchburg
Roanoke
Charleston
Augusta
Columbia
Wilmington
Hatteras
Cape Henry
Cape May
Atlantic City
Bermuda
Havana
Cienfuegos
Santiago de Cuba
Key West
Miami
Jacksonville
Tallahassee
Apalachicola
Thomasville
Meridian
Vicksburg
Monterey
Chihuahua
Durango
Mazatlan
Guaymas
Nogales
Yuma
Prescott
Flagstaff
Albuquerque
Santa Fe
Las Vegas
Pueblo
Colorado Springs
Canon City
Leadville
Grand Junction
Salt Lake City
Ogden
Cheyenne
Denver
Pueblo
Trinidad
Amarillo

Chart VIII. Total Snowfall, Inches, April, 1920.

Chart IX. Weather Map of North Atlantic Ocean, April 5, 1920.

(Plotted by F. A. Young.)

Chart IX. Weather Map of North Atlantic Ocean, April 5, 1920.

(Plotted by F. A. Young.)

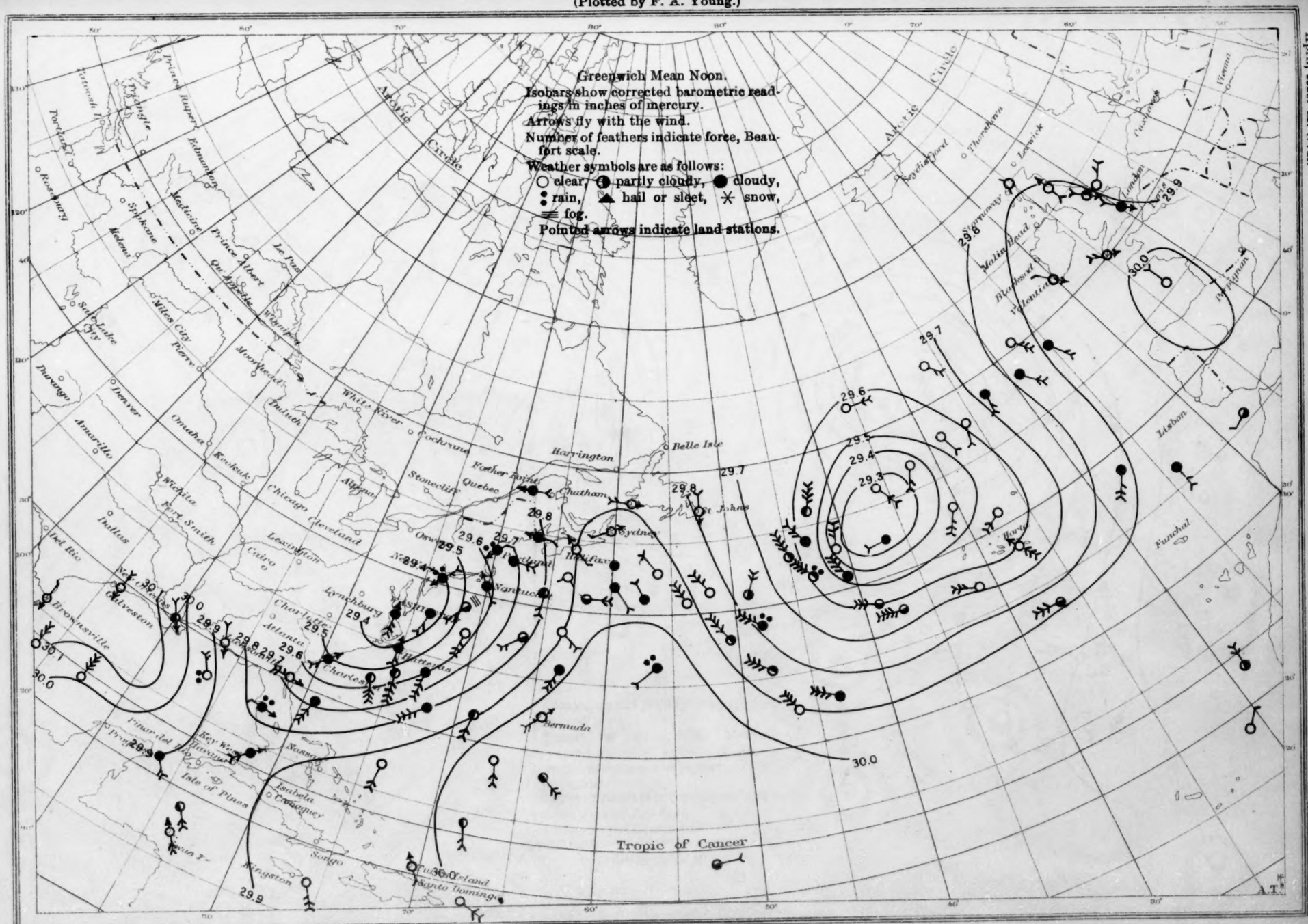


Chart X. Weather Map of North Atlantic Ocean, April 6, 1920.

(Plotted by F. A. Young.)

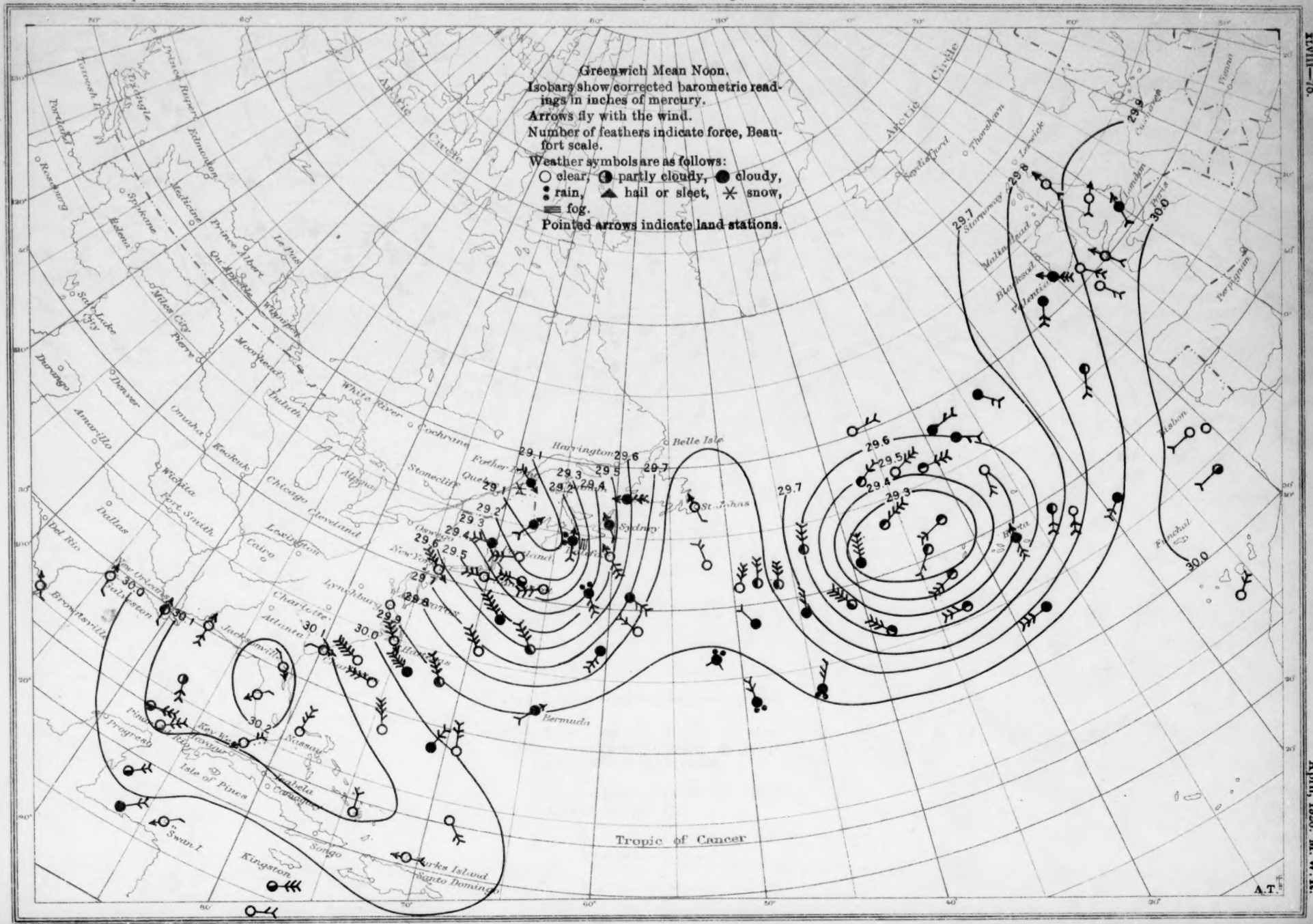

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
A.T.

Chart XI. Weather Map of North Atlantic Ocean, April 10, 1920.

(Plotted by F. A. Young.)

Chart XI. Weather Map of North Atlantic Ocean, April 10, 1920.

(Plotted by F. A. Young.)

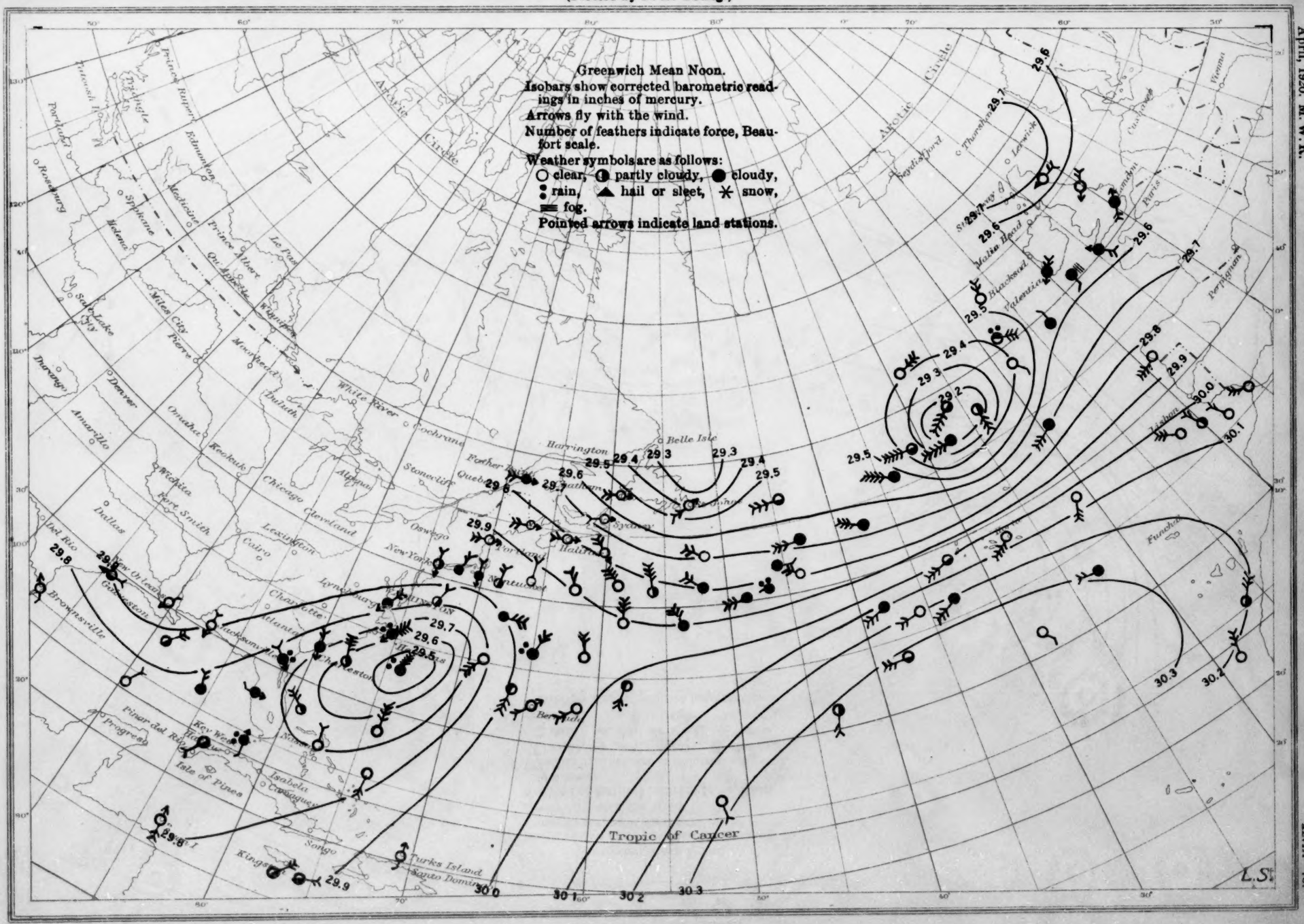

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
L.S.

Chart XII. Weather Map of North Atlantic Ocean, April 11, 1920.

(Plotted by F. A. Young.)

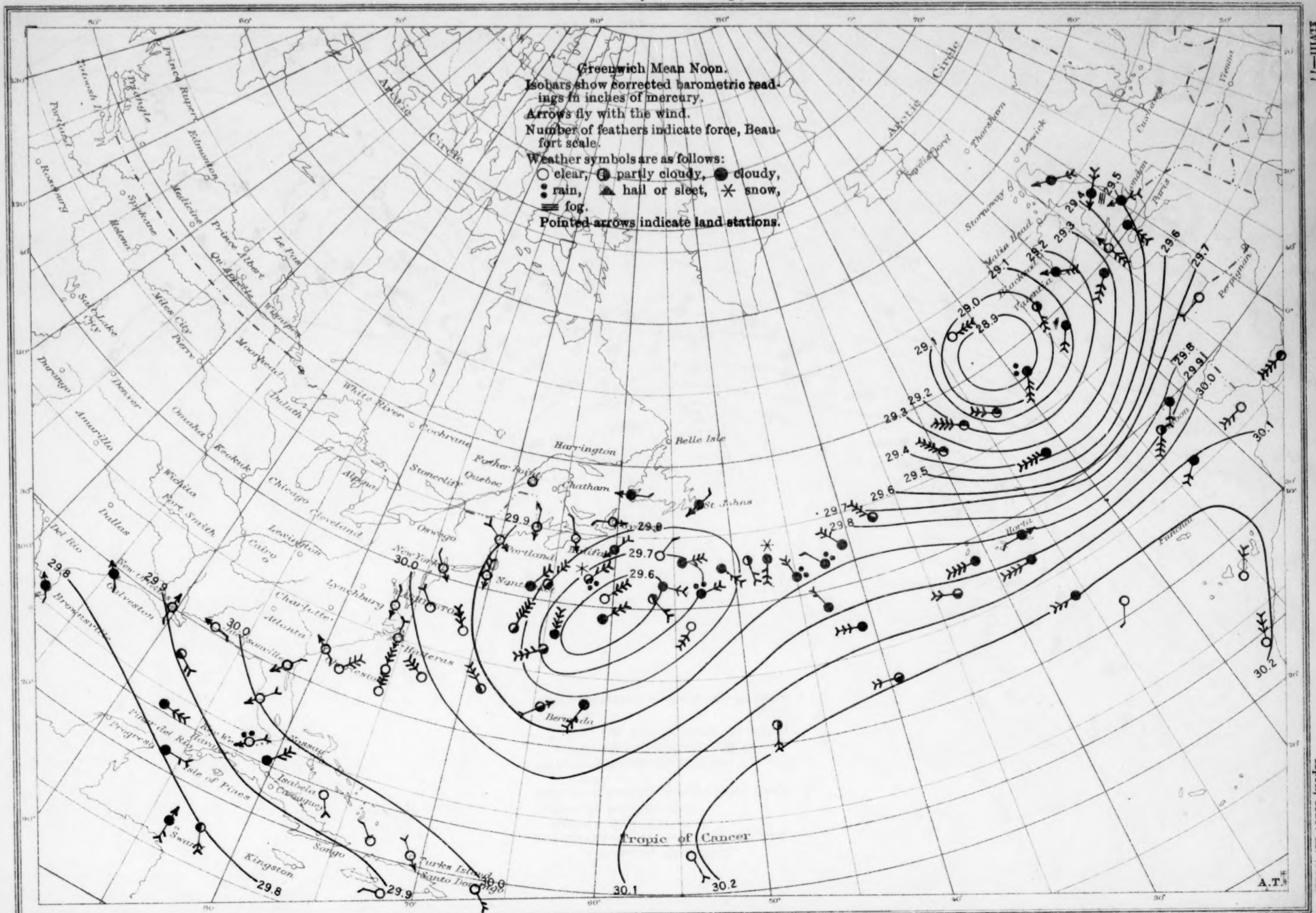

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
A.T.

Chart XIII. Weather Map of North Atlantic Ocean, April 12, 1920.

Chart XIII. Weather Map of North Atlantic Ocean, April 12, 1920.

(Plotted by F. A. Young.)

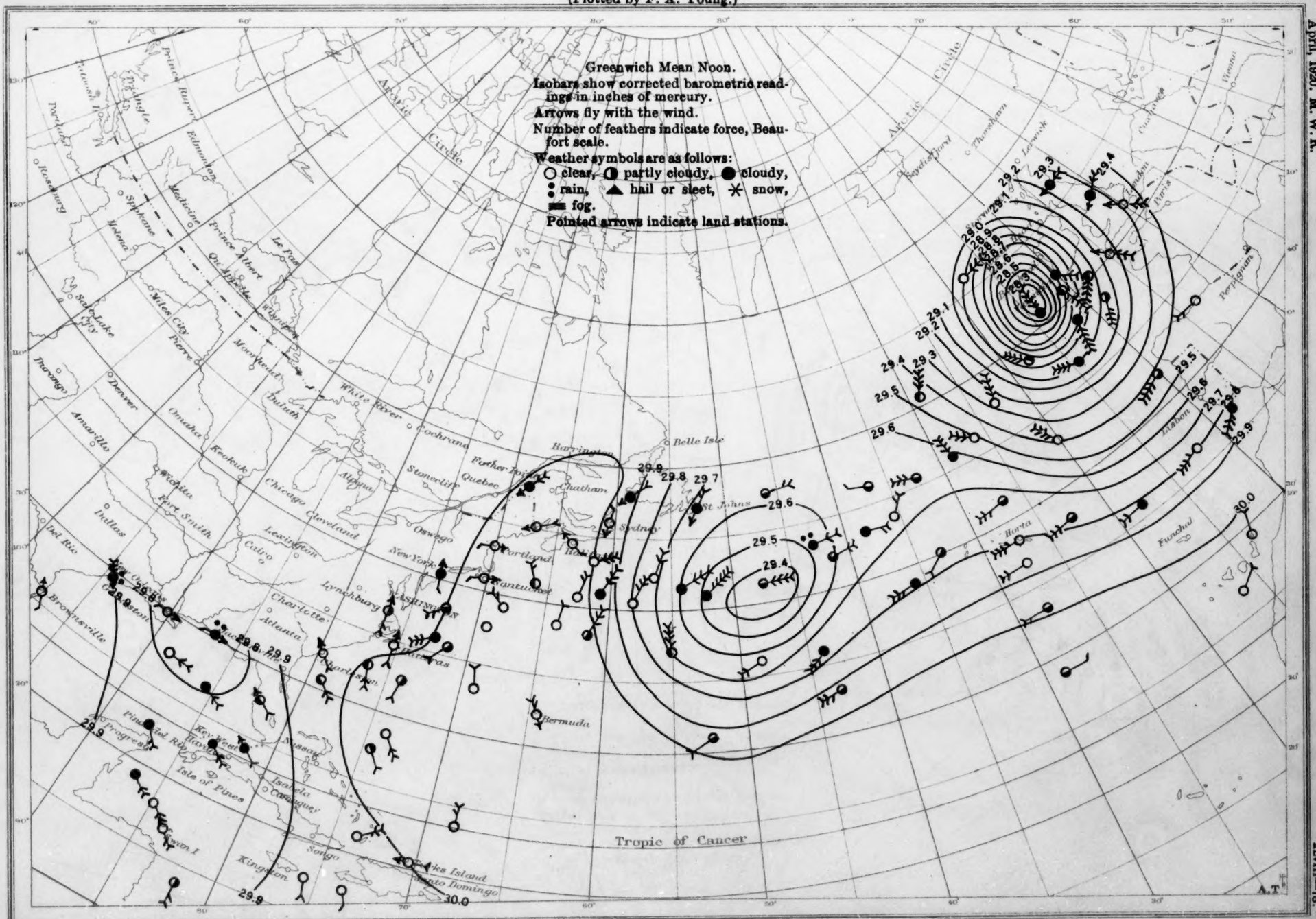

Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Tropic of Cancer
Arctic Circle
Belle Isle
Bermuda
Nassau
Isle of Pines
Key West
Tampa
Jacksonville
Charleston
Wilmington
Norfolk
Washington
Baltimore
Philadelphia
New York
Boston
Portland
Halifax
St. Johns
Sydney
Quebec
Father Point
Chatham
Harrington
Stonecliffe
Cochrane
White River
Duluth
Minneapolis
Moorhead
Winnipeg
Prince Albert
Edmonton
Medicine Hat
Swift Current
Battleford
Prince Rupert
Victoria
Seattle
Portland
Roseburg
Eureka
Salt Lake City
Miles City
Pierre
Omaha
Denver
Durango
Amarillo
Dallas
Del Rio
Brownsville
Galveston
Port Arthur
New Orleans
Vicksburg
Memphis
Little Rock
Fort Smith
Wichita
Kansas City
Chicago
Cleveland
Oswego
Buffalo
Toronto
Kamloops
Nelson
Kootenay
Lethbridge
Calgary
Edmonton
Prince Albert
Battleford
Swift Current
Moosejaw
Regina
Qu'Appelle
Winnipeg
Brandon
Prince Rupert
Port Simpson
Ketchikan
Juneau
Sitka
Dawson
Fort Yukon
Barrow
Point Hope
Nome
Unalaska
Kodiak
Sand Point
Valdez
Seward
Fairbanks
Tanana
Nulato
Kotzebue
Bethel
Kuskokwim
Iliamna
Cordova
Yakutat
Juneau
Ketchikan
Port Simpson
Prince Rupert
Victoria
Seattle
Portland
Roseburg
Eureka
Salt Lake City
Miles City
Pierre
Omaha
Denver
Durango
Amarillo
Dallas
Del Rio
Brownsville
Galveston
Port Arthur
New Orleans
Vicksburg
Memphis
Little Rock
Fort Smith
Wichita
Kansas City
Chicago
Cleveland
Oswego
Buffalo
Toronto
Kamloops
Nelson
Kootenay
Lethbridge
Calgary
Edmonton
Prince Albert
Battleford
Swift Current
Moosejaw
Regina
Qu'Appelle
Winnipeg
Brandon
Duluth
Minneapolis
Moorhead
Winnipeg
Prince Albert
Edmonton
Medicine Hat
Swift Current
Battleford

Chart XIV. Weather Map of North Atlantic Ocean, April 13, 1920.

(Plotted by F. A. Young.)

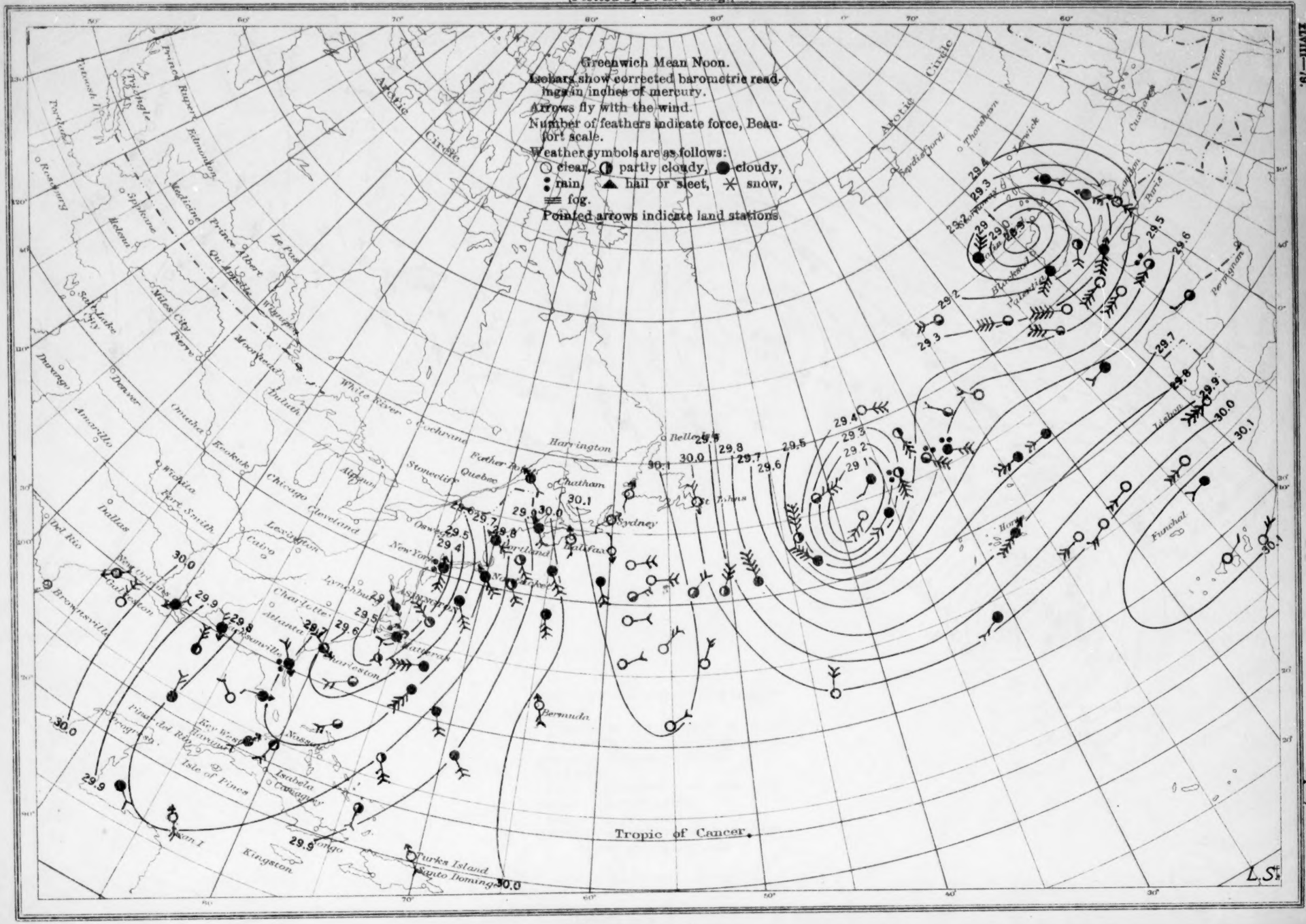
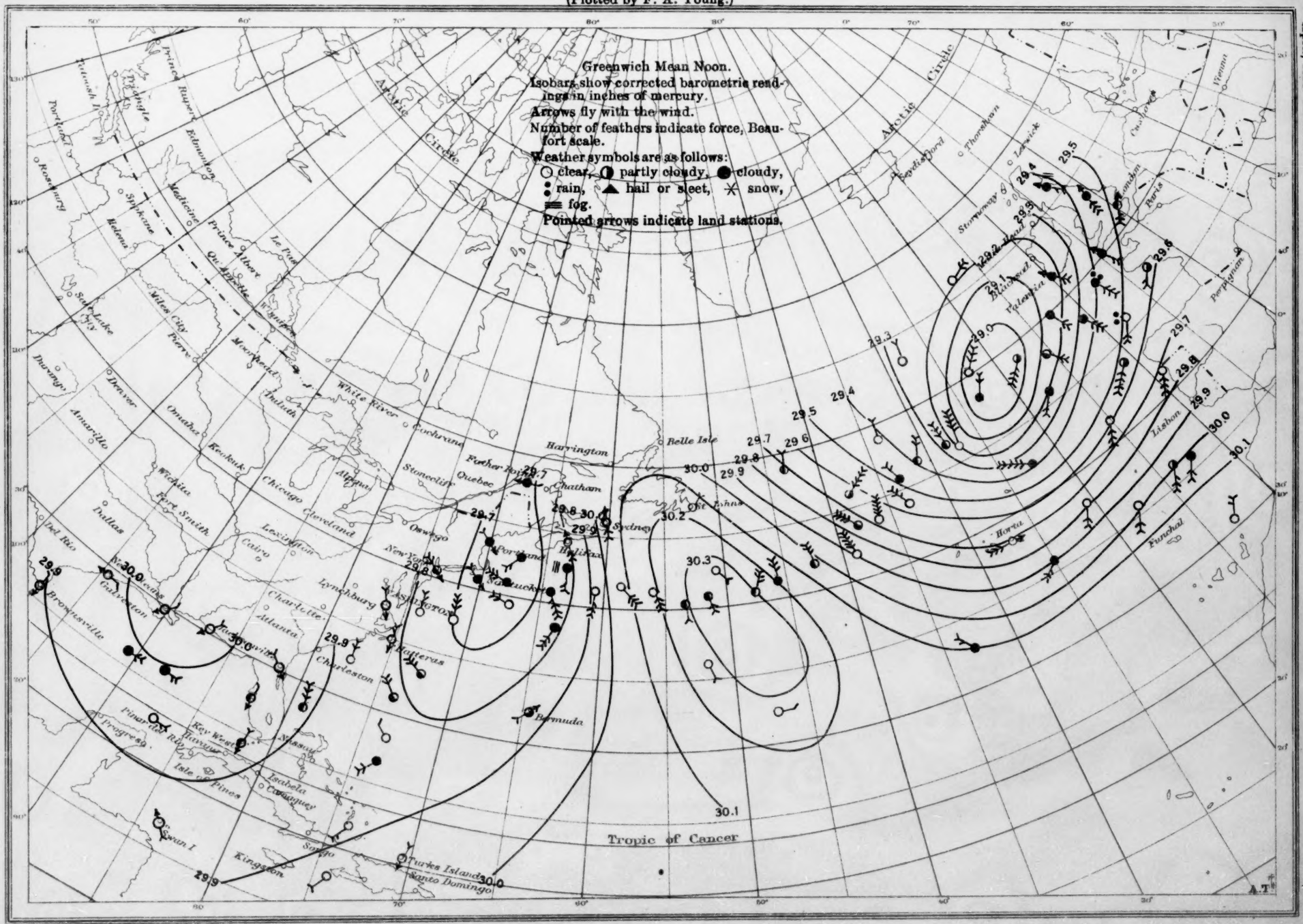


Chart XV. Weather Map of North Atlantic Ocean April 14, 1920.

Chart XV. Weather Map of North Atlantic Ocean April 14, 1920.

(Plotted by F. A. Young.)


Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail or sleet, snow,
fog.
Pointed arrows indicate land stations.
Arctic Circle
Tropic of Cancer
Belle Isle
Harrington
Cochrane
Father Point
Quebec
Chatham
Stonecliff
Alpena
Chicago
Cleveland
Oswego
Portland
Boston
New York
Halifax
Sydney
St. John's
Bermuda
Hatteras
Charleston
Atlanta
Charlotte
Lynchburg
Washington
Key West
Havana
Isabela
Caibarien
Isle of Pines
Turks Island
Santo Domingo
Kingston
Progreso
Pinar del Rio
Brownsville
Galveston
Del Rio
Dallas
Fort Smith
Wichita
Kansas City
Omaha
Denver
Durango
Amarillo
Duluth
White River
Moosejaw
Prince Albert
Medicine Hat
Swift Current
Edmonton
Prince Rupert
Victoria
Tatoosh
Seattle
Portland
Roseburg
Salt Lake City
Helena
Winnipeg
Port Arthur
Sault Ste. Marie
Parry Sound
Toronto
Buffalo
Rochester
Albany
Portland
Eastport
Sydney
Halifax
St. John's